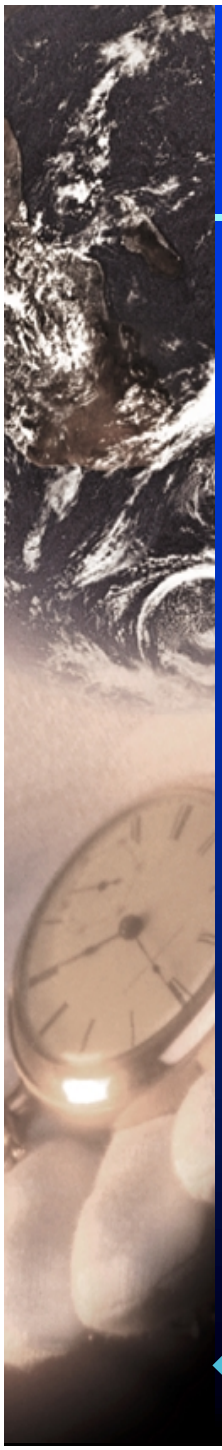


2000 International ADAMS Users Conference

Linking ADAMS/Car and ADVISOR for Advanced Vehicle Evaluation

Keith Wipke

Senior Engineer, Vehicle Systems Analysis Team

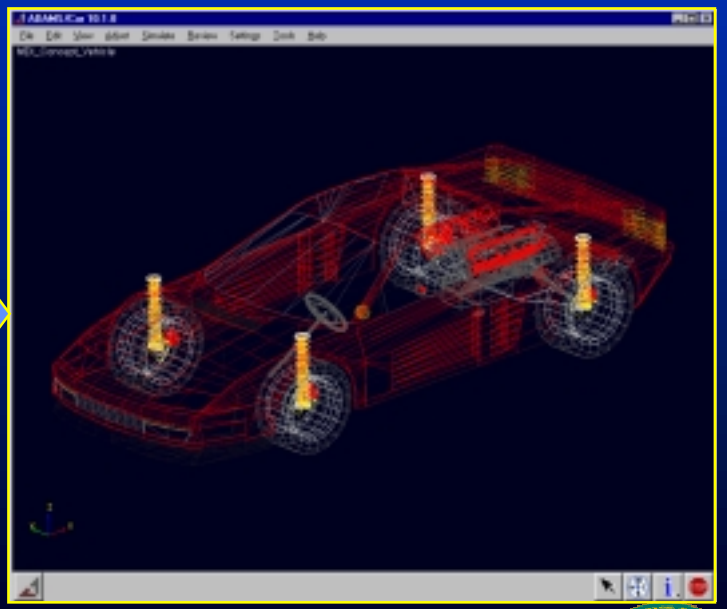
National Renewable Energy Laboratory

NREL

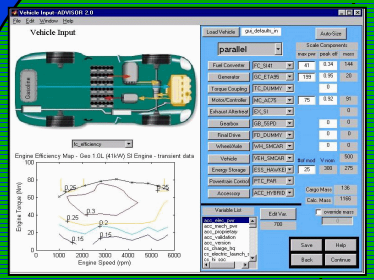
Center for Transportation Technologies and Systems

Presentation Outline

- Background and demonstration of ADVISOR 2.2
- Example of previous linkage with packaging
- Objectives of linking ADVISOR and ADAMS/Car
- Two approaches to making linkage
  - ADAMS/ADVISOR Co-simulation
  - Export to ADAMS/Car

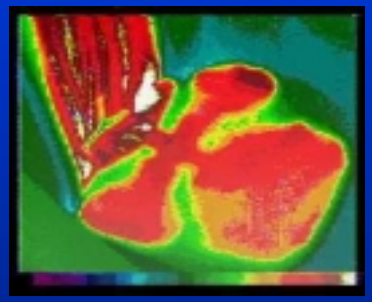


Light-Duty Hybrid Electric Vehicle Program

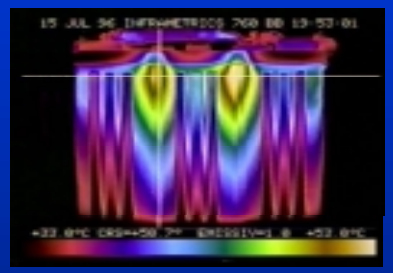


Vehicle Systems Analysis

Digital Functional Vehicle



Vehicle Climate Control



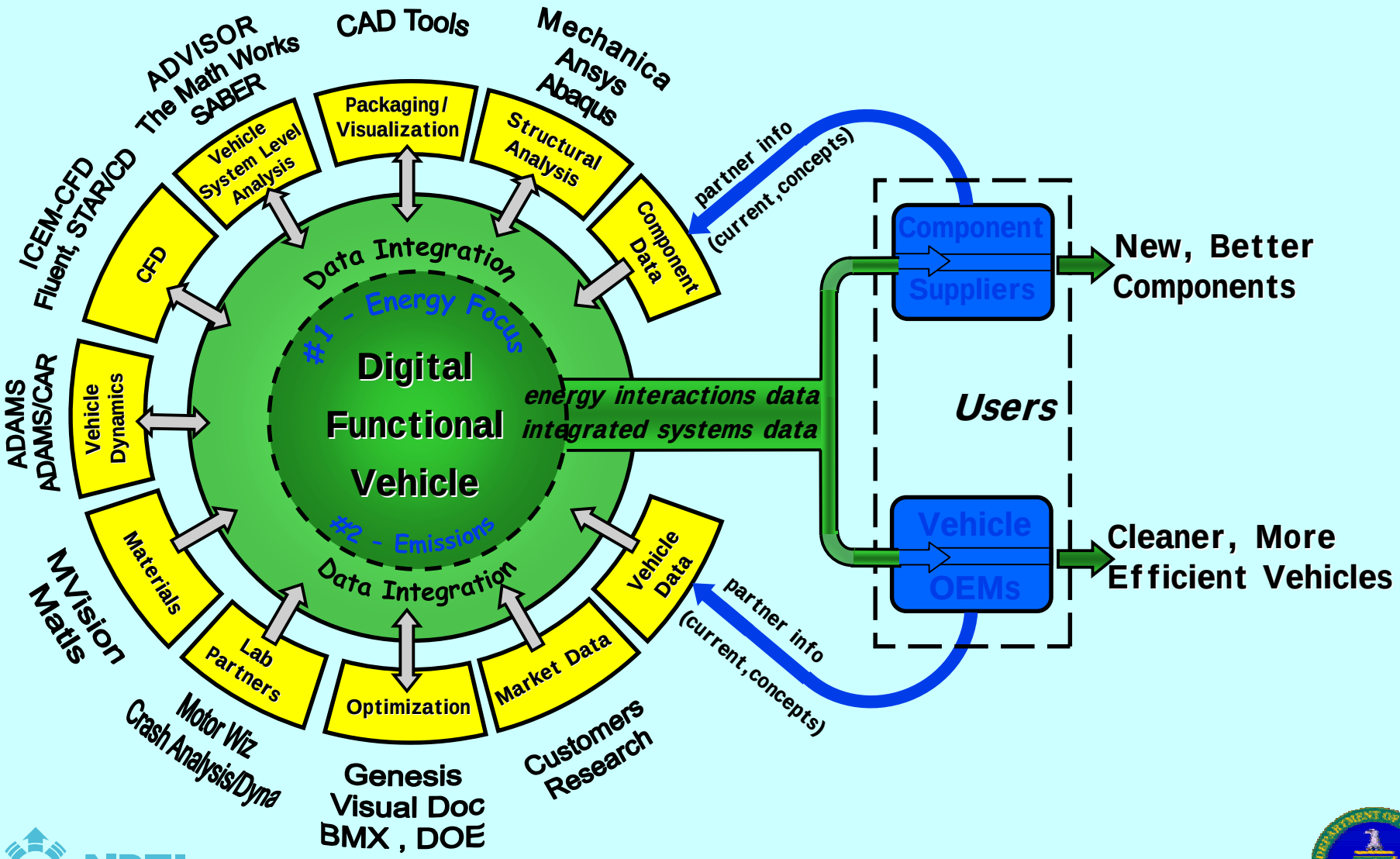
Battery Thermal Management

Big 3 Partnership
(55 mpg, mid-size vehicle)

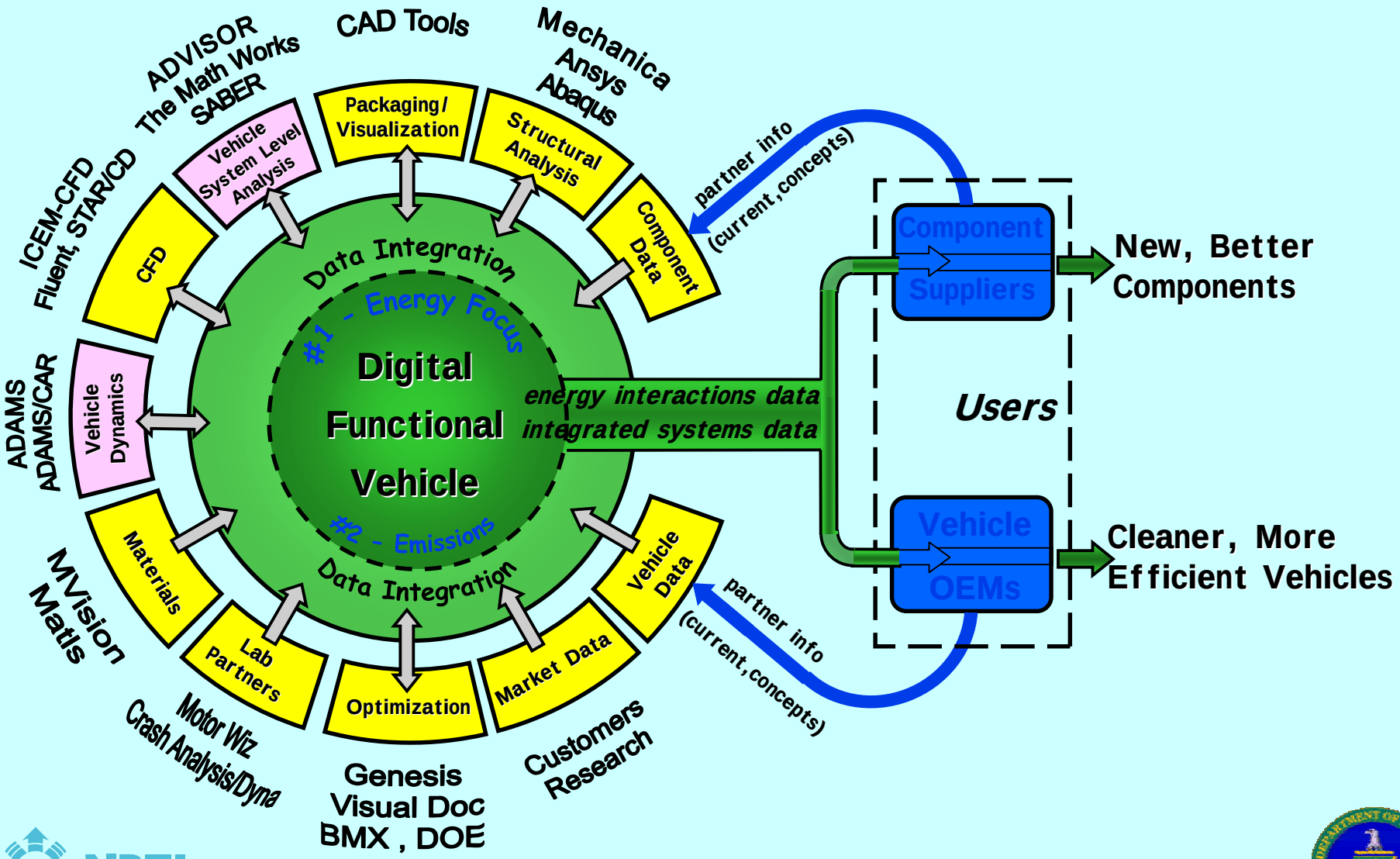
NREL

CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS

Digital Functional Vehicle Data Integration Wheel

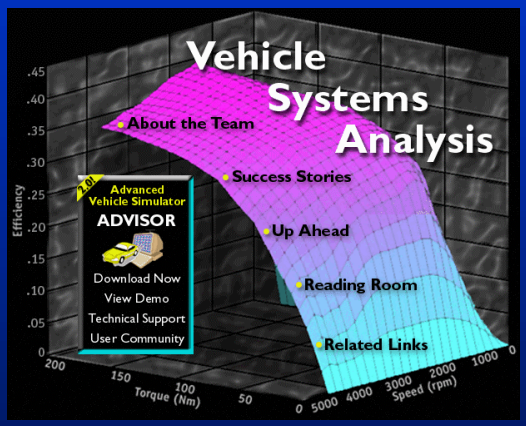


Digital Functional Vehicle Wheel: Linking Systems Level Analysis with Vehicle Dynamics



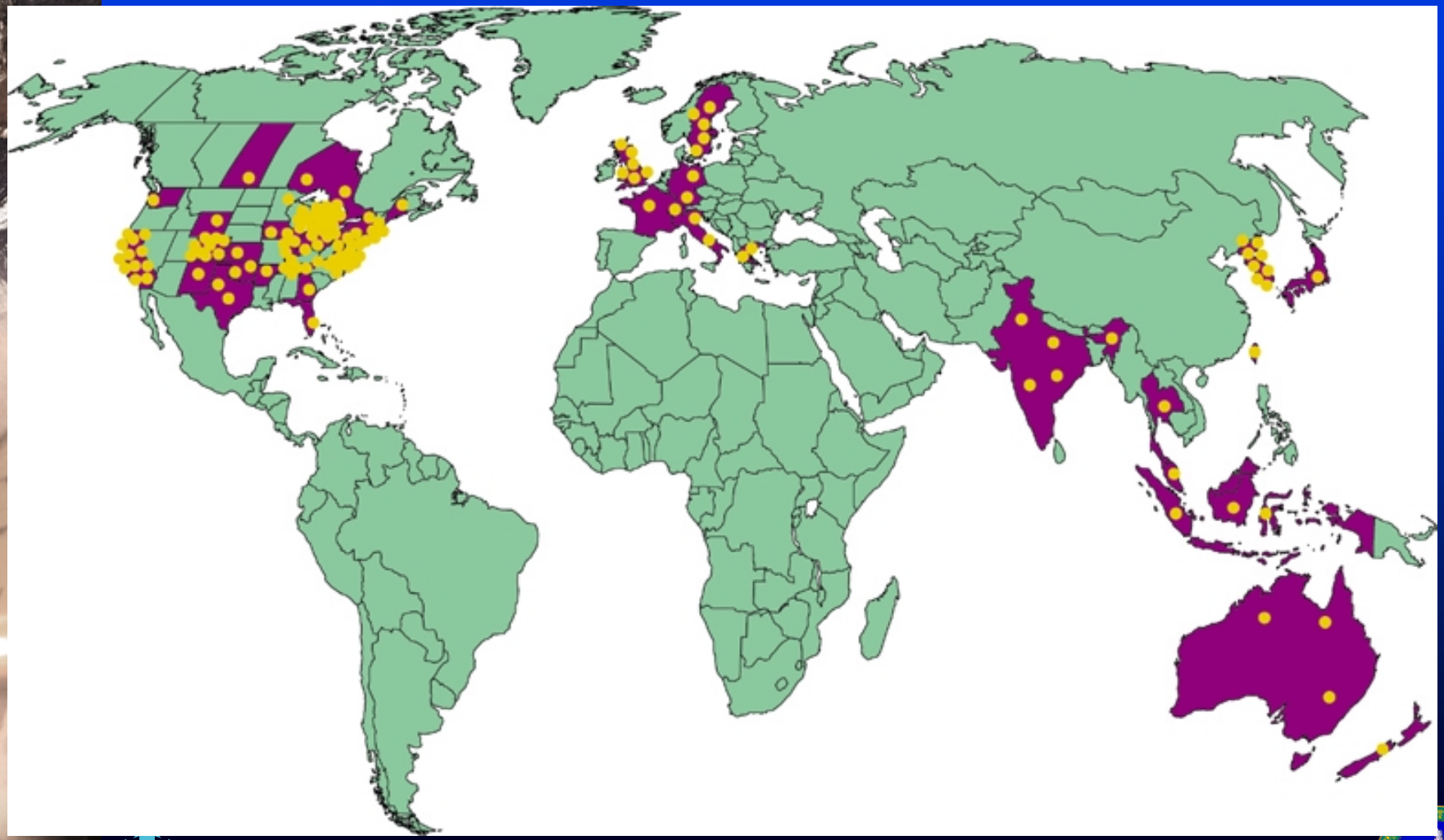
Background on ADVISOR

- ADVISOR = ADvanced VehIcle SimulatOR
  - simulates conventional, electric, or hybrid vehicles (series, parallel, or fuel cell)
- ADVISOR was created in 1994 to support DOE Hybrid Program at NREL
- Released on vehicle systems analysis web site in September, 1998

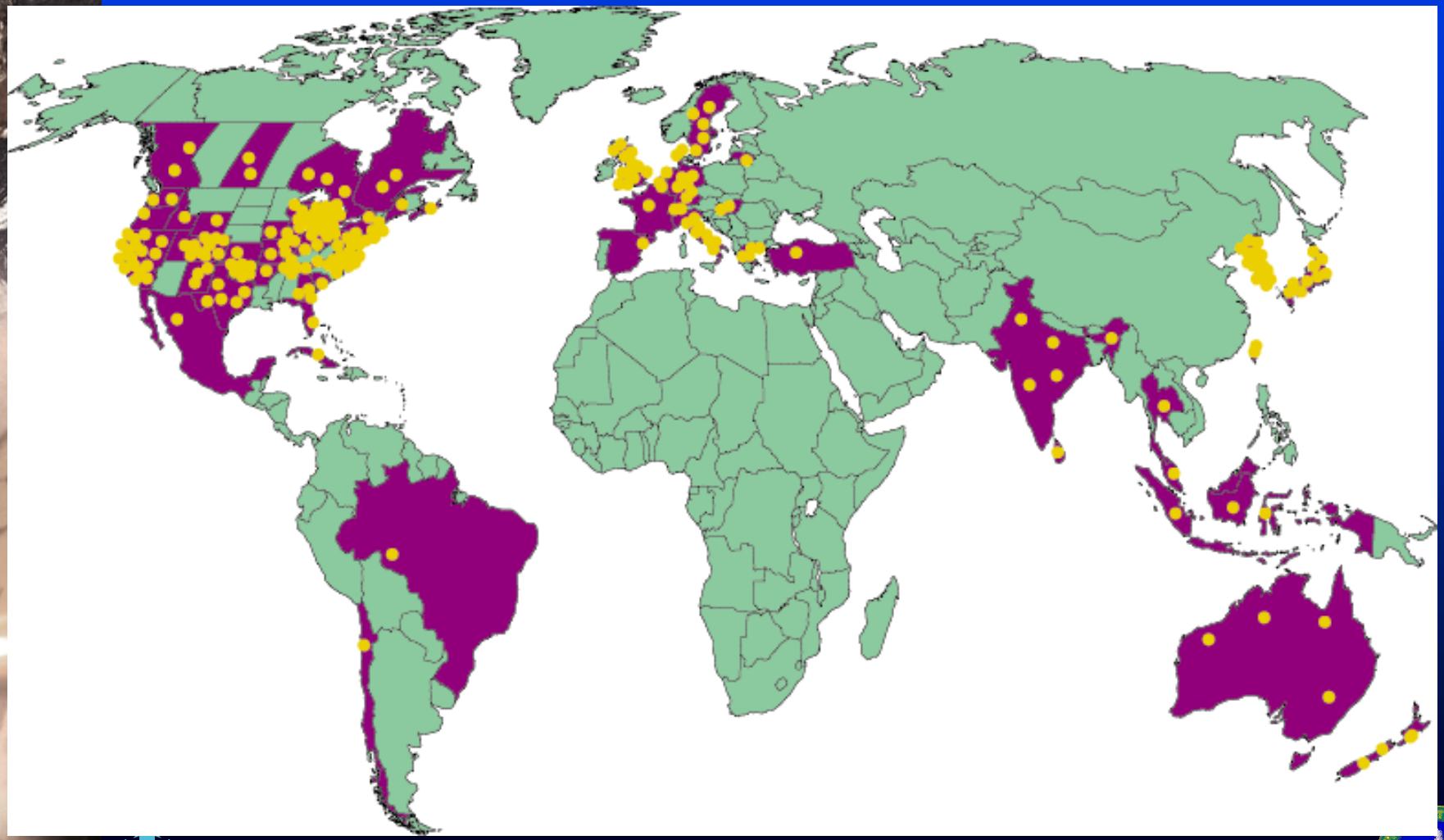


- Programmed in MATLAB/Simulink
- Downloaded by over 1700 people around world
- Users help provide component data and validation

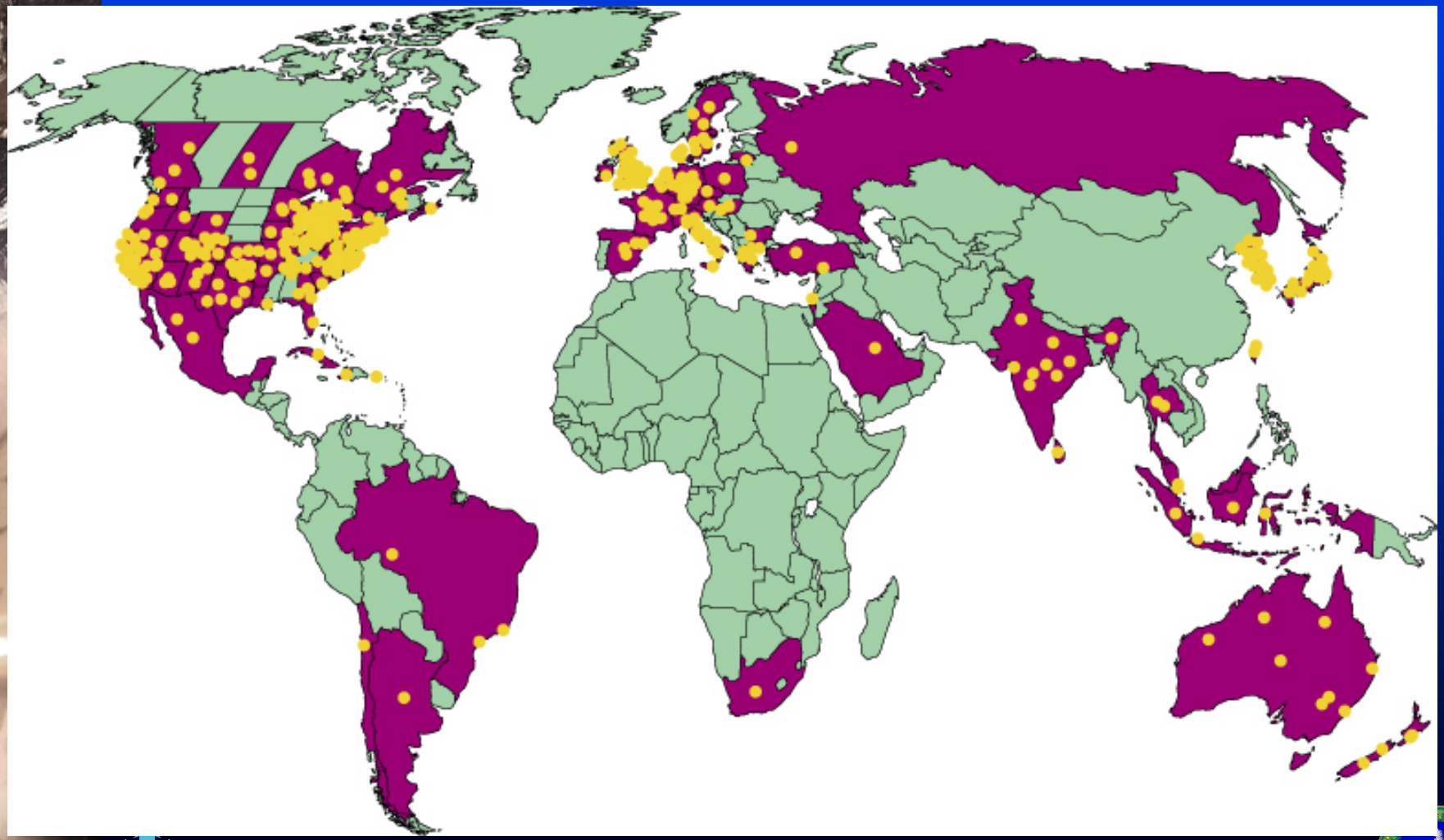
ADVISOR Being Used Globally
November 1998: ~130 users



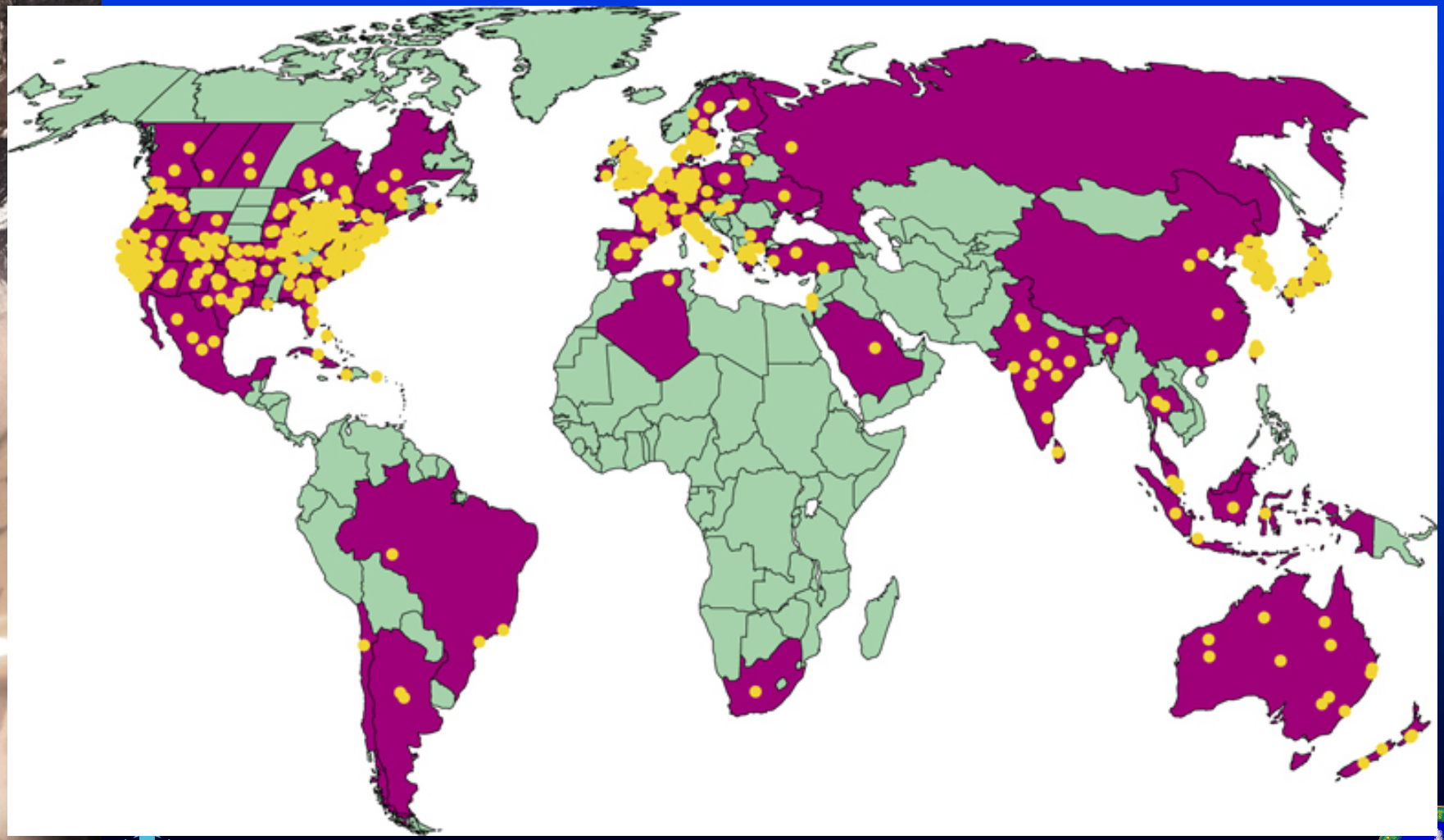
ADVISOR Being Used Globally
January 1999: ~330 users



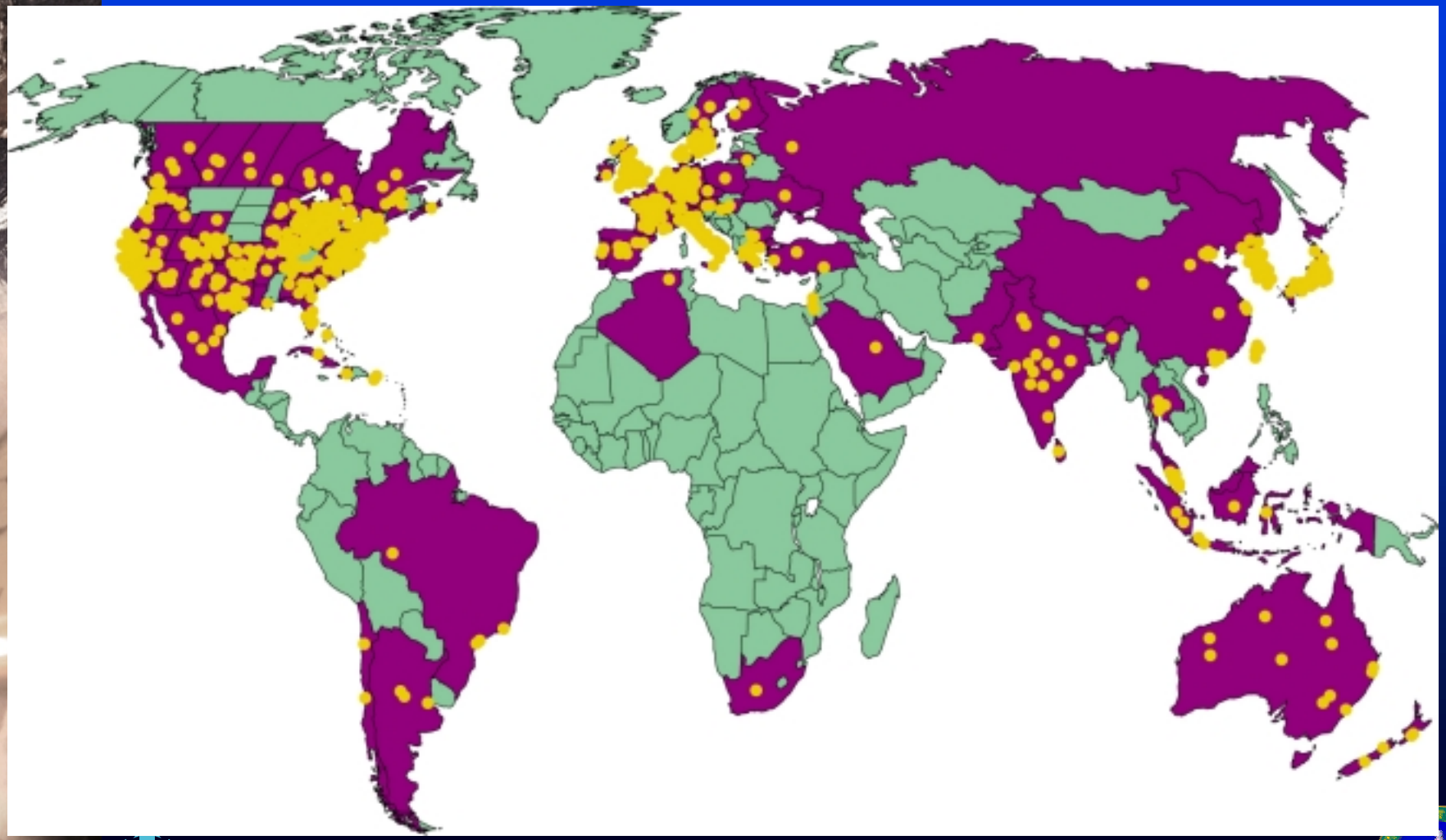
ADVISOR Being Used Globally
March 1999: ~500 users



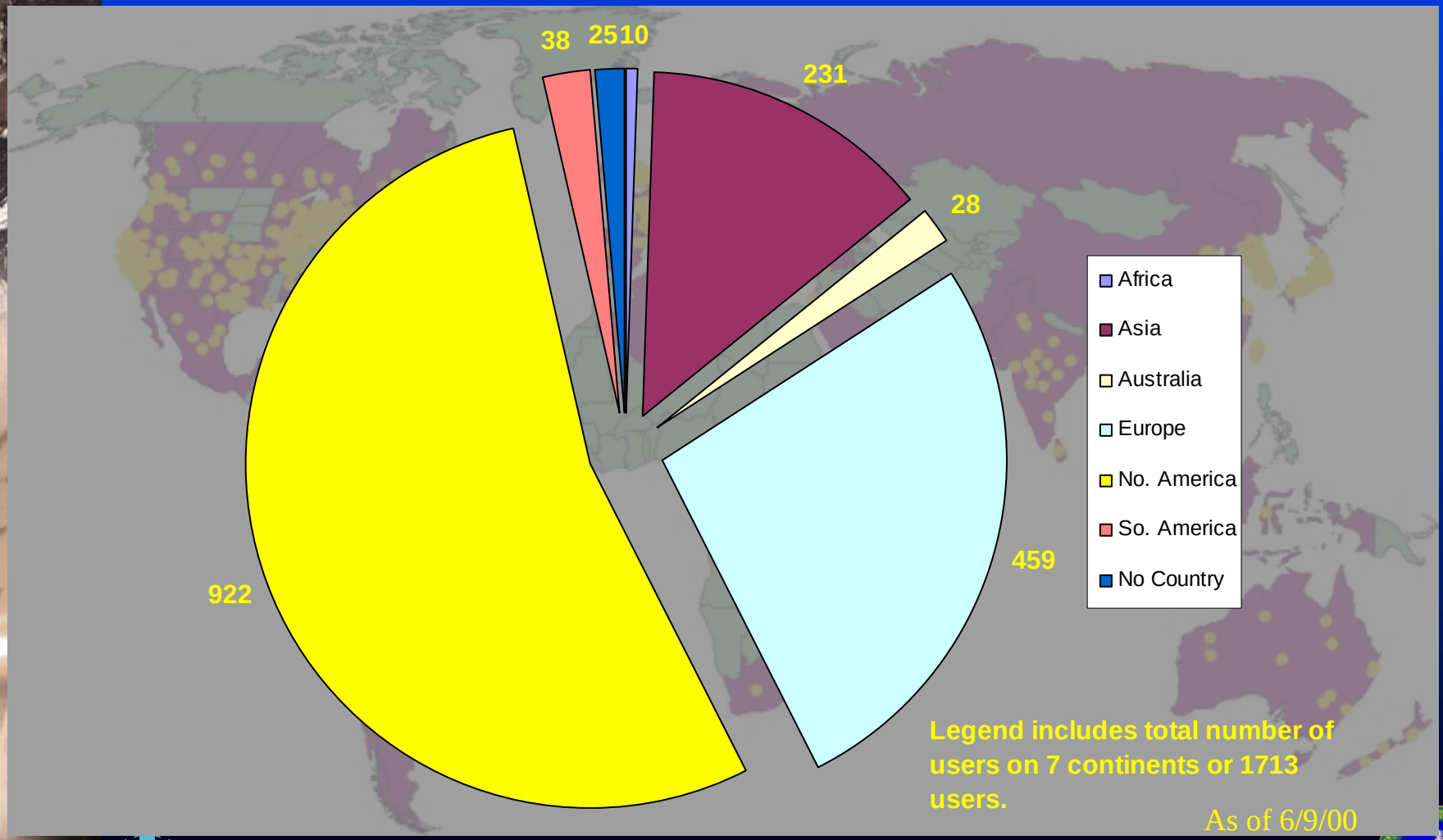
ADVISOR Being Used Globally
August 1999: ~800 users



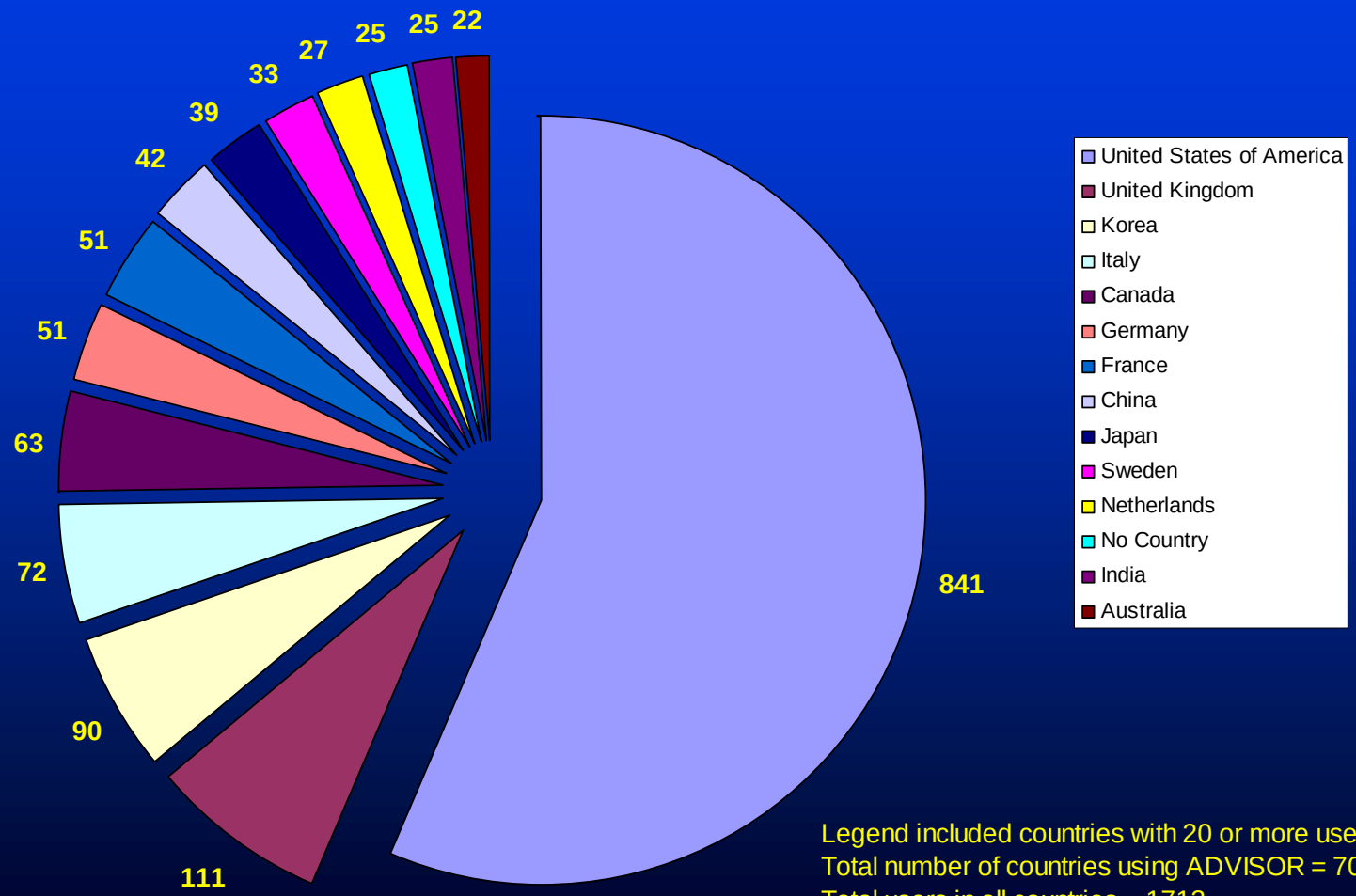
ADVISOR Being Used Globally
June 2000: ~1700 users



ADVISOR Downloads by Continent



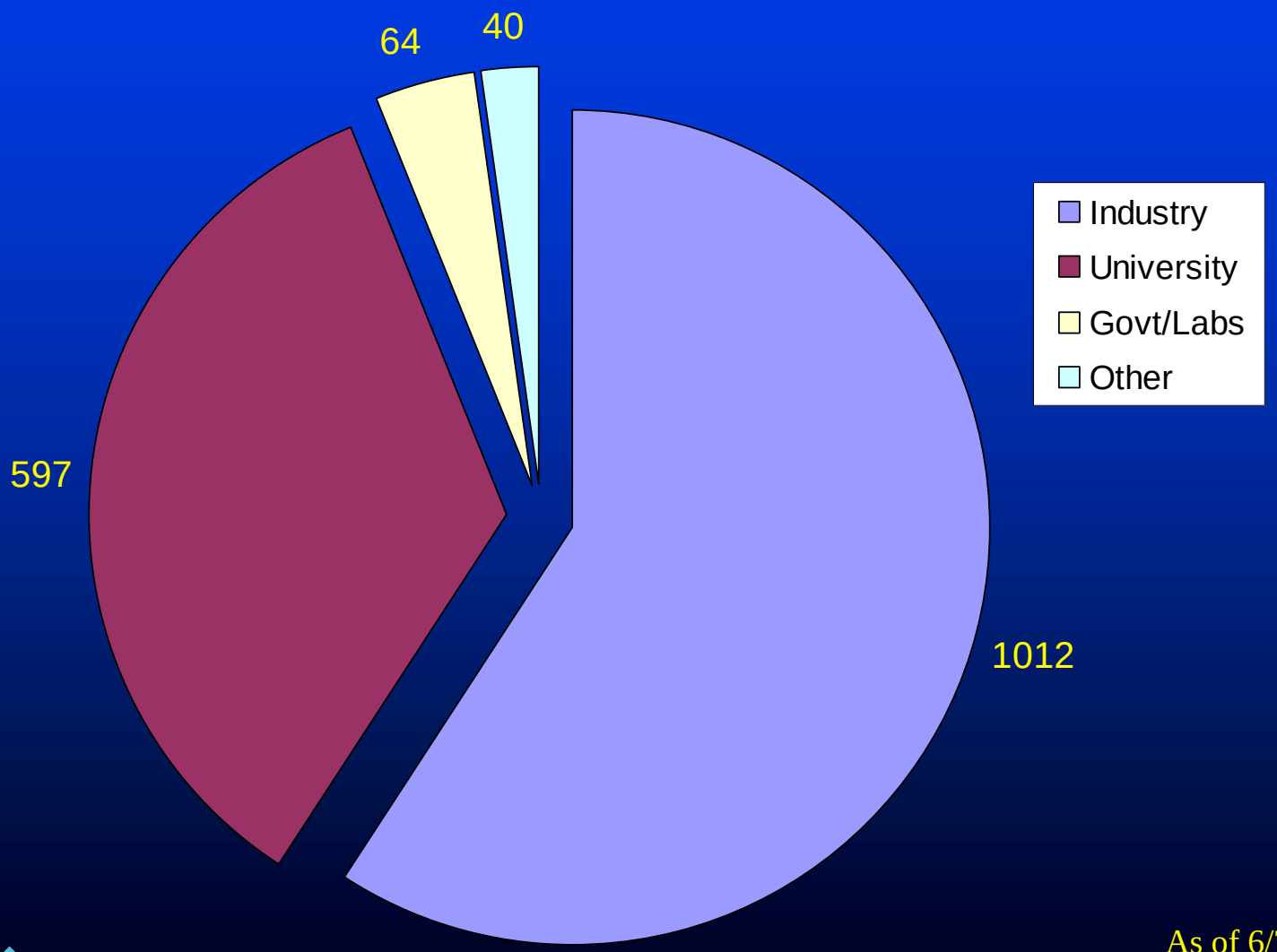
ADVISOR Downloads by Country



Legend included countries with 20 or more users
Total number of countries using ADVISOR = 70
Total users in all countries = 1713

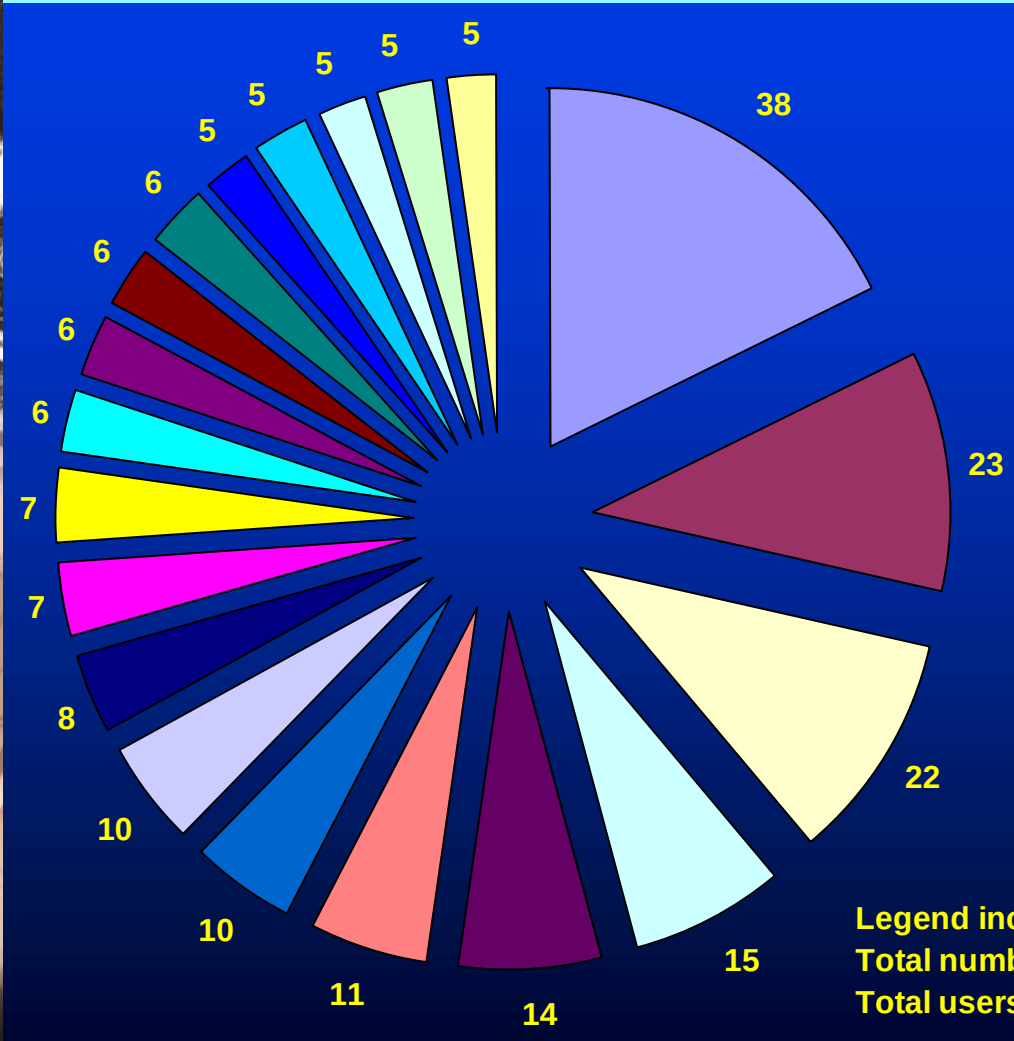
As of 6/7/00

ADVISOR Downloads by Type of Organization



As of 6/7/00

ADVISOR Downloads by Industry



- Ford Motor Company
- DaimlerChrysler Corporation
- General Motors
- Visteon
- Delphi Automotive Systems
- Volvo Car Corporation
- FIAT Research Center, Italy
- Hyundai Motor Company
- AVL
- Parametric Technologies Corporation
- Siemens Automotive Systems
- AlliedSignal
- Honda
- Renault
- Technologies M4 Inc.
- Epyx Corporation
- Hino Motors, Ltd.
- Nissan Motor Company
- Self-Employed
- TNO Automotive

Legend includes industry with 5 or more users
Total number of companies using ADVISOR = 577
Total users in all industries = 1012

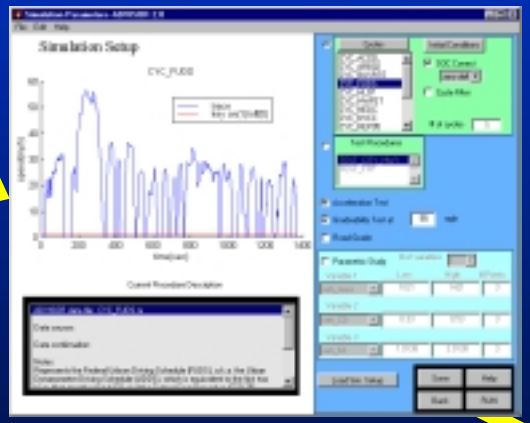
As of 6/7/00

ADVISOR Users Conference: August 2000

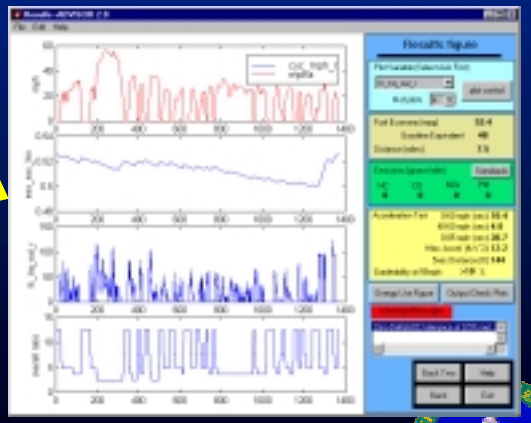
Three Main ADVISOR Screens (Roadmap)

Vehicle Input

Simulation Setup

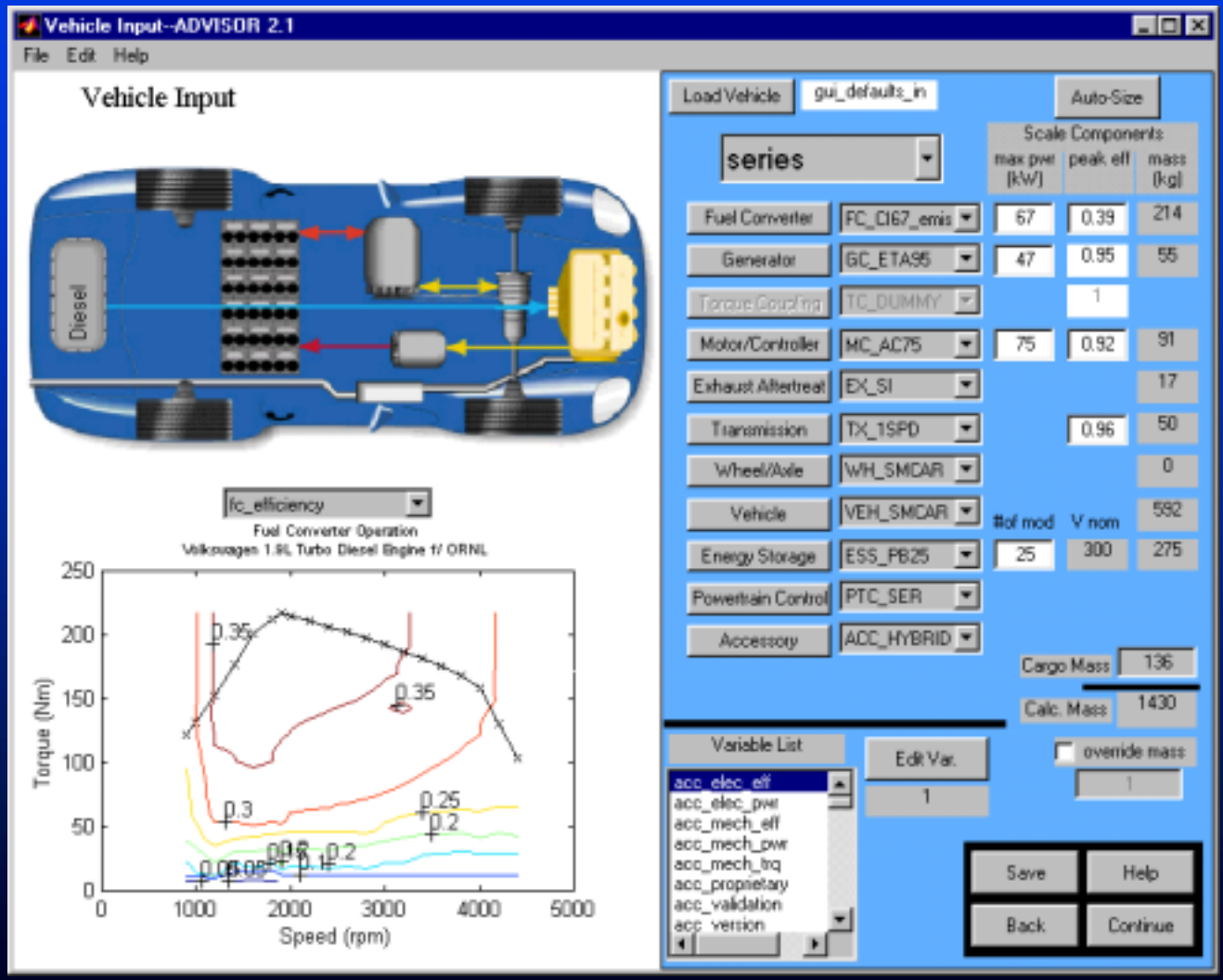


Results

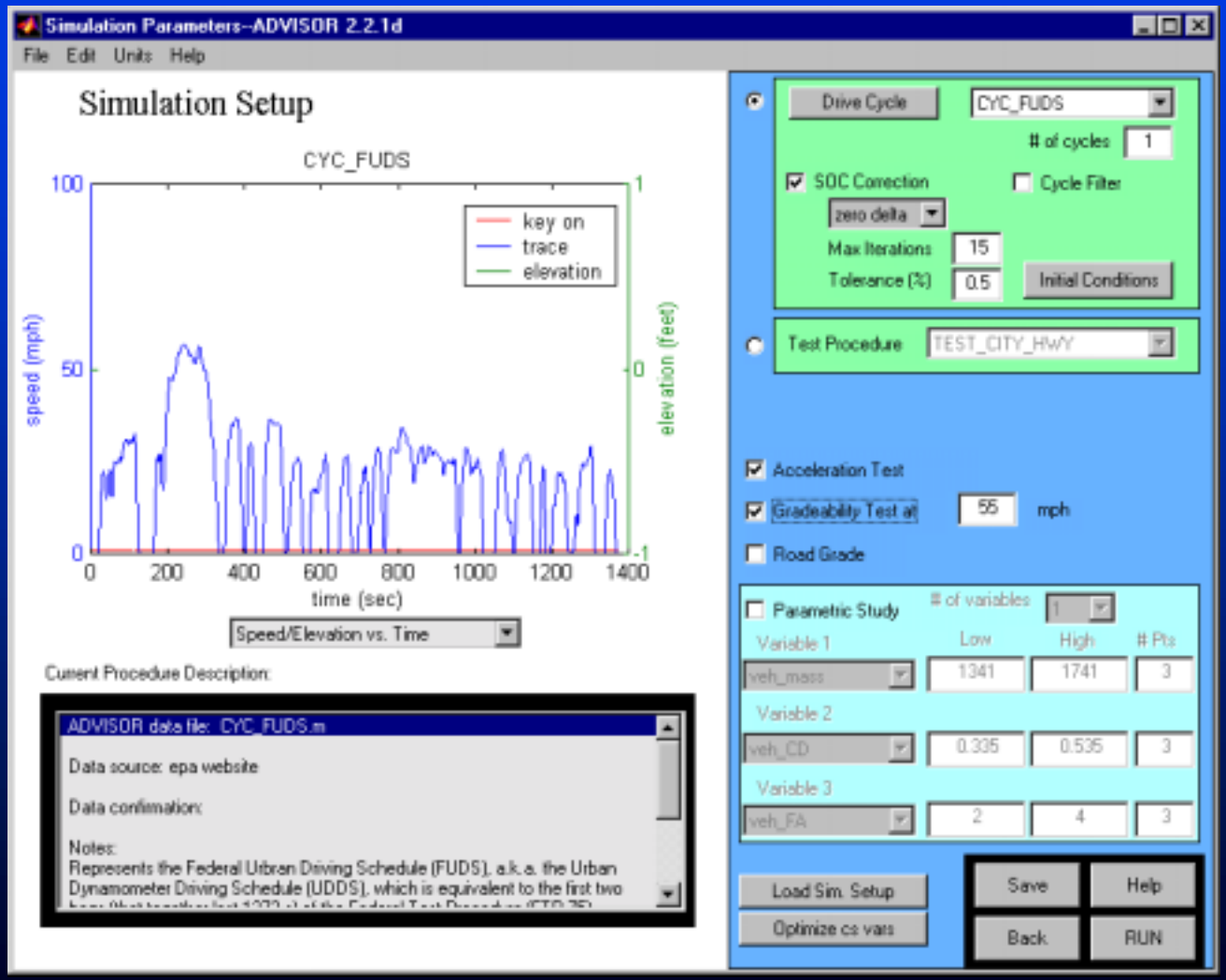


ADVISOR Demonstration

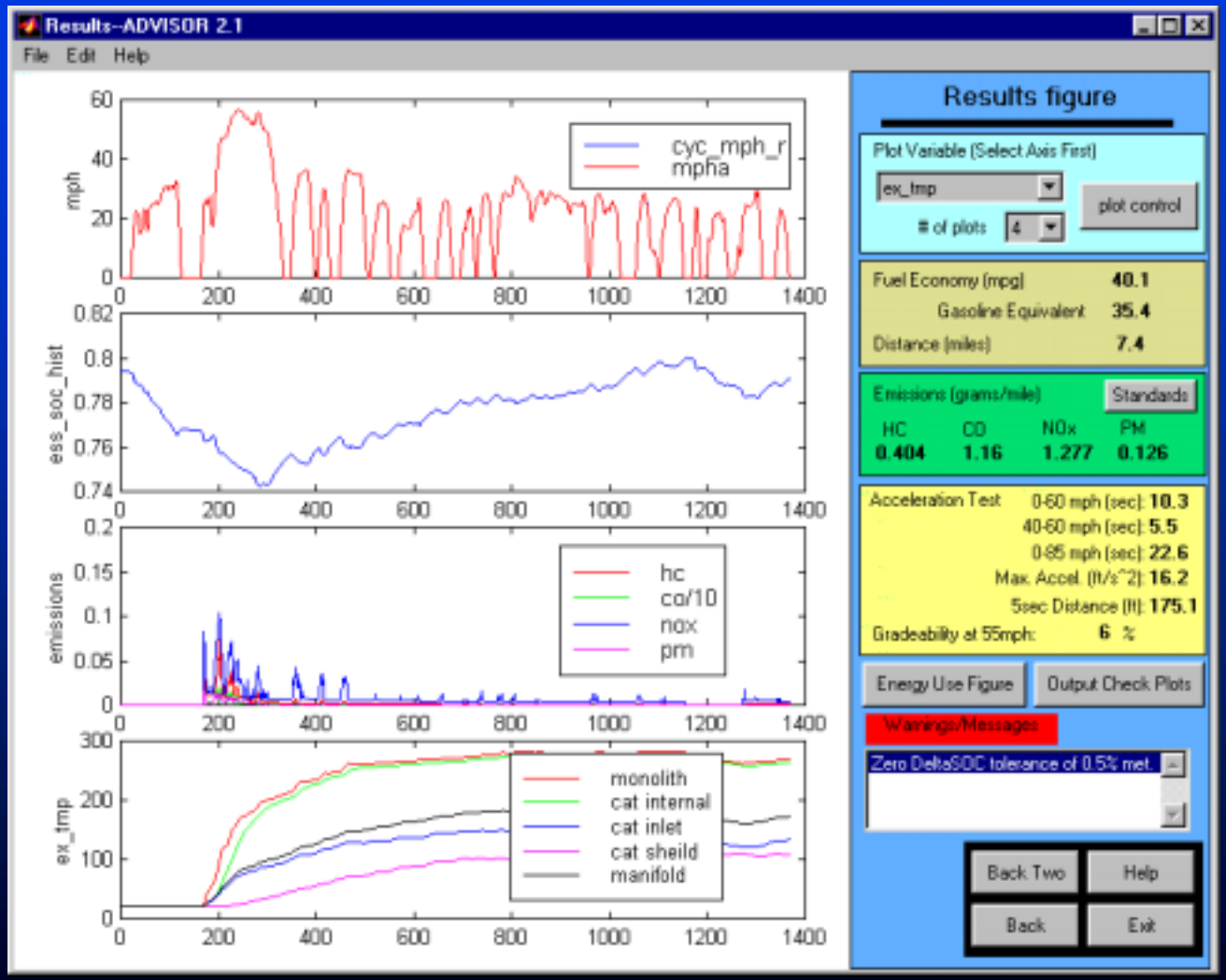
Vehicle Input Screen



Simulation Setup Screen

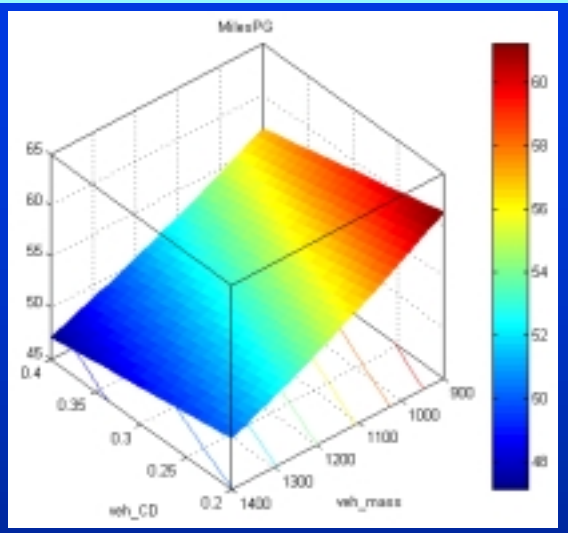


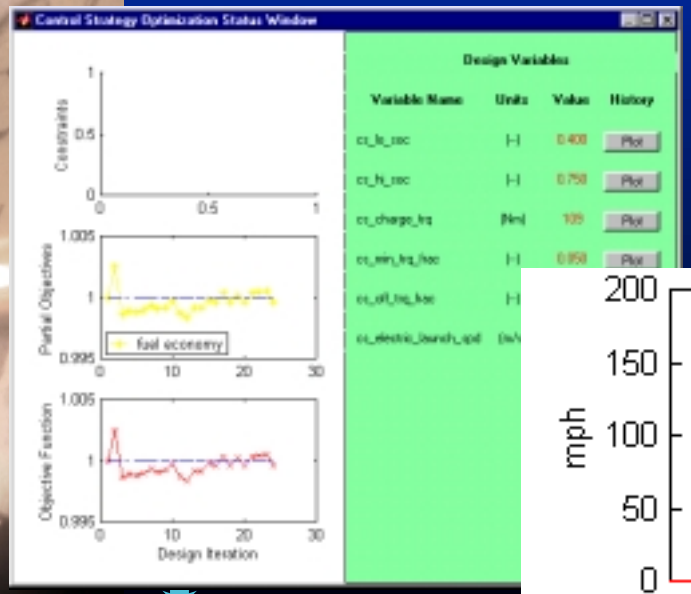
Cycle Results Screen

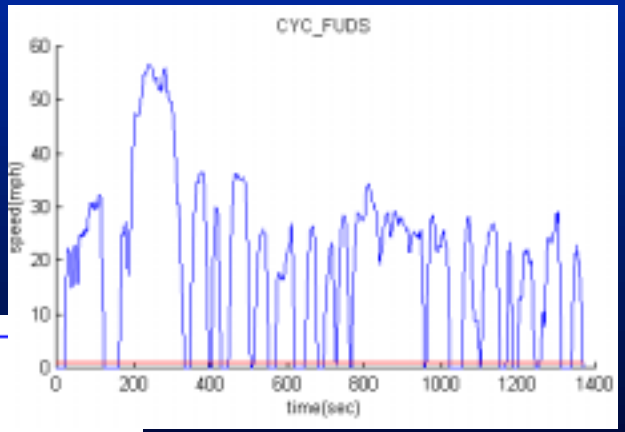


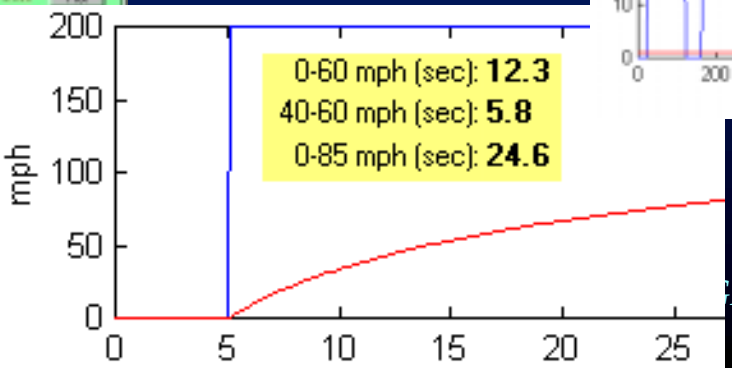
Types of Simulation Tests Possible

- Parametric sweeps
- Drive cycles
- Acceleration and grade tests
- Control Strategy Optimizations

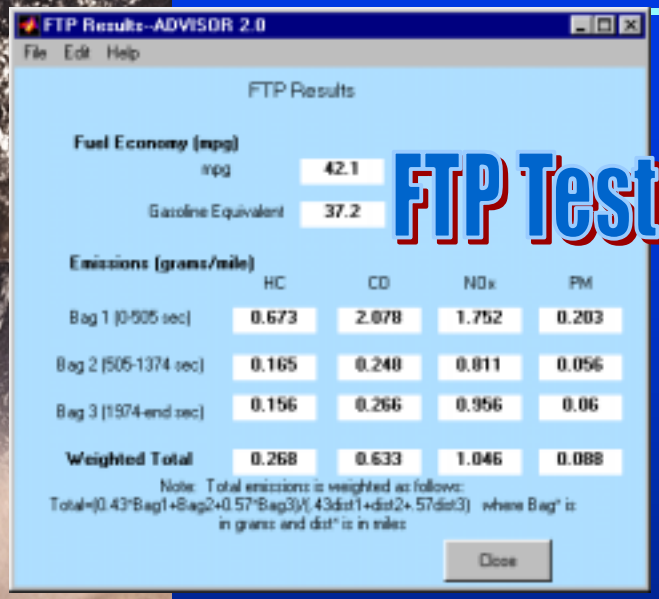






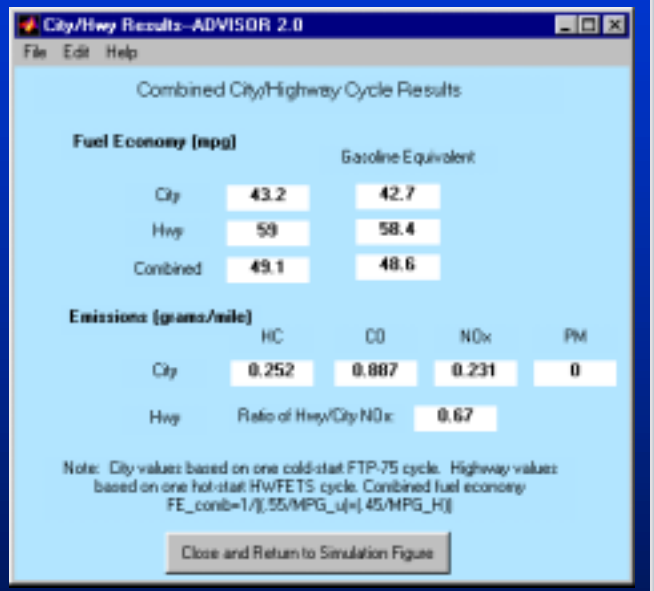


"Test Procedures" Currently Available

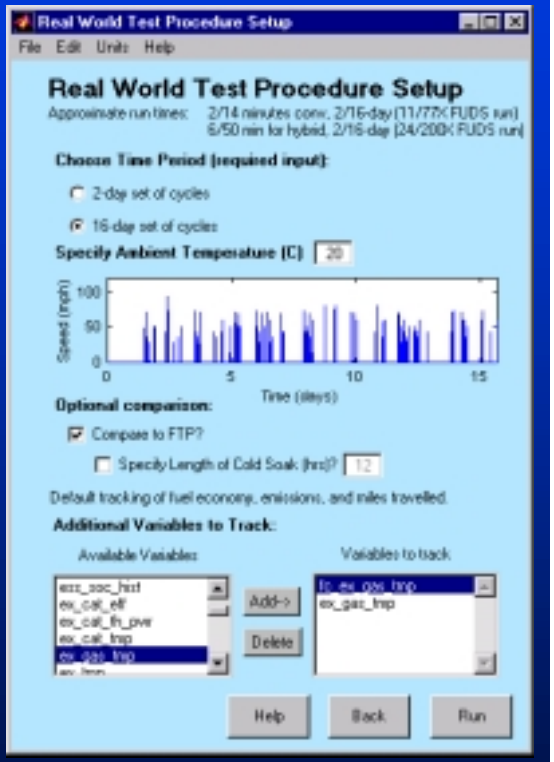


FTP Test

Combined City/Highway



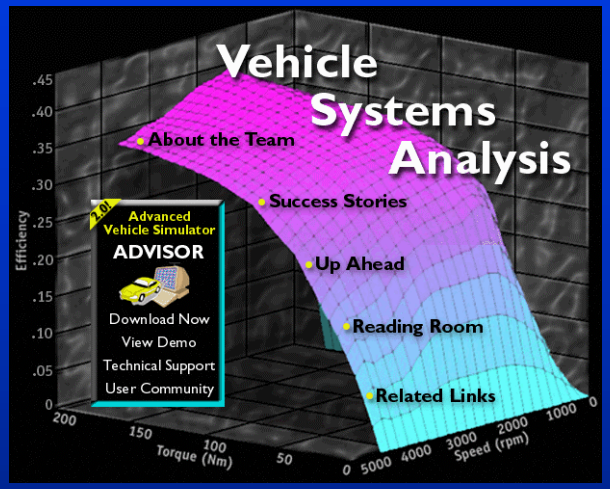
Real World



SAE J1711 HEV Test Procedure

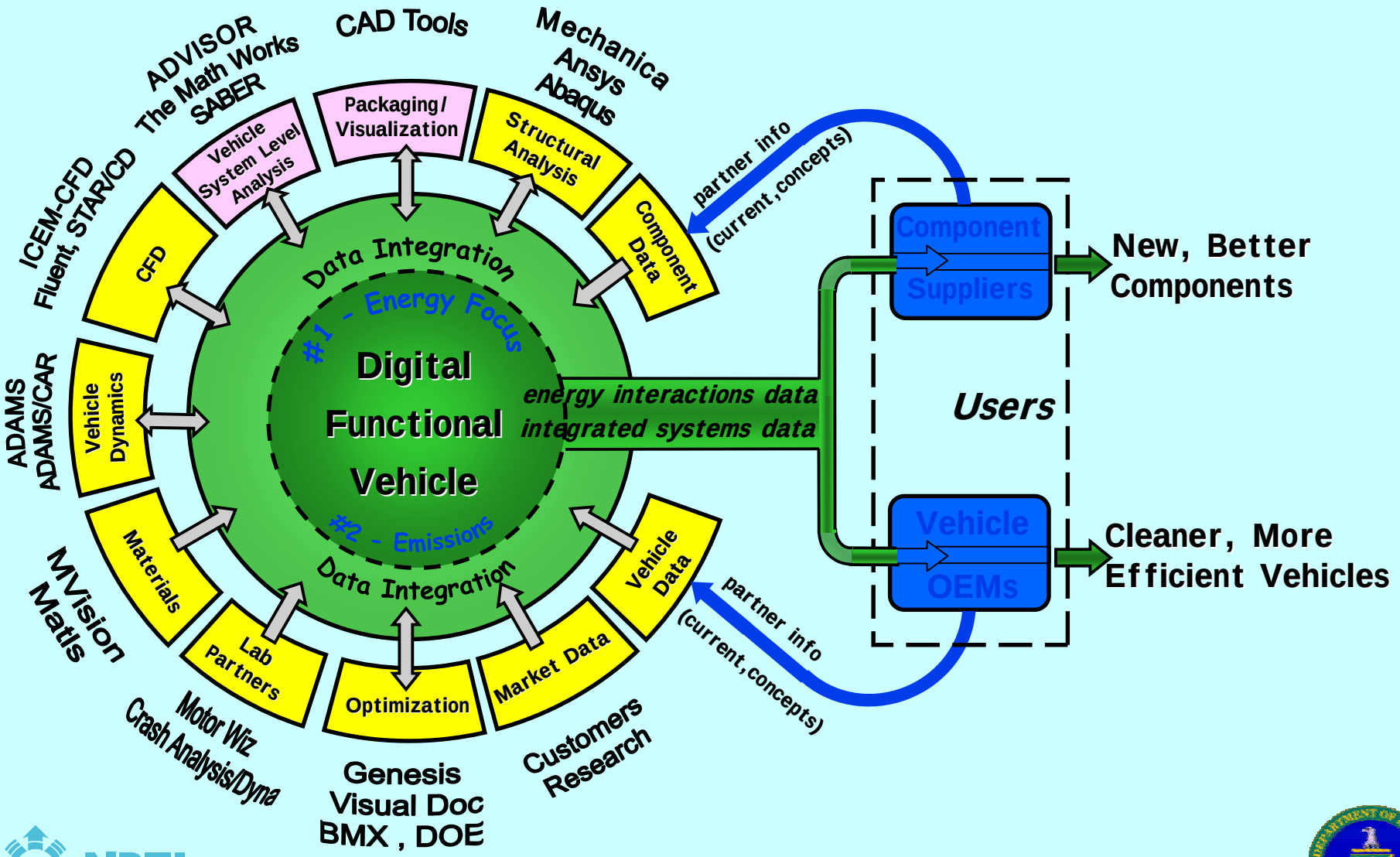
Software Availability on Web

- NREL's Vehicle Systems Analysis web site launched in September 1998
- ADVISOR 2.2 available for free after filling out simple form (incl. source code)
- 'Forum' has bulletin area for questions to be answered and files to be shared
- Documentation viewable from web site
- Reading room has all papers and presentations from team



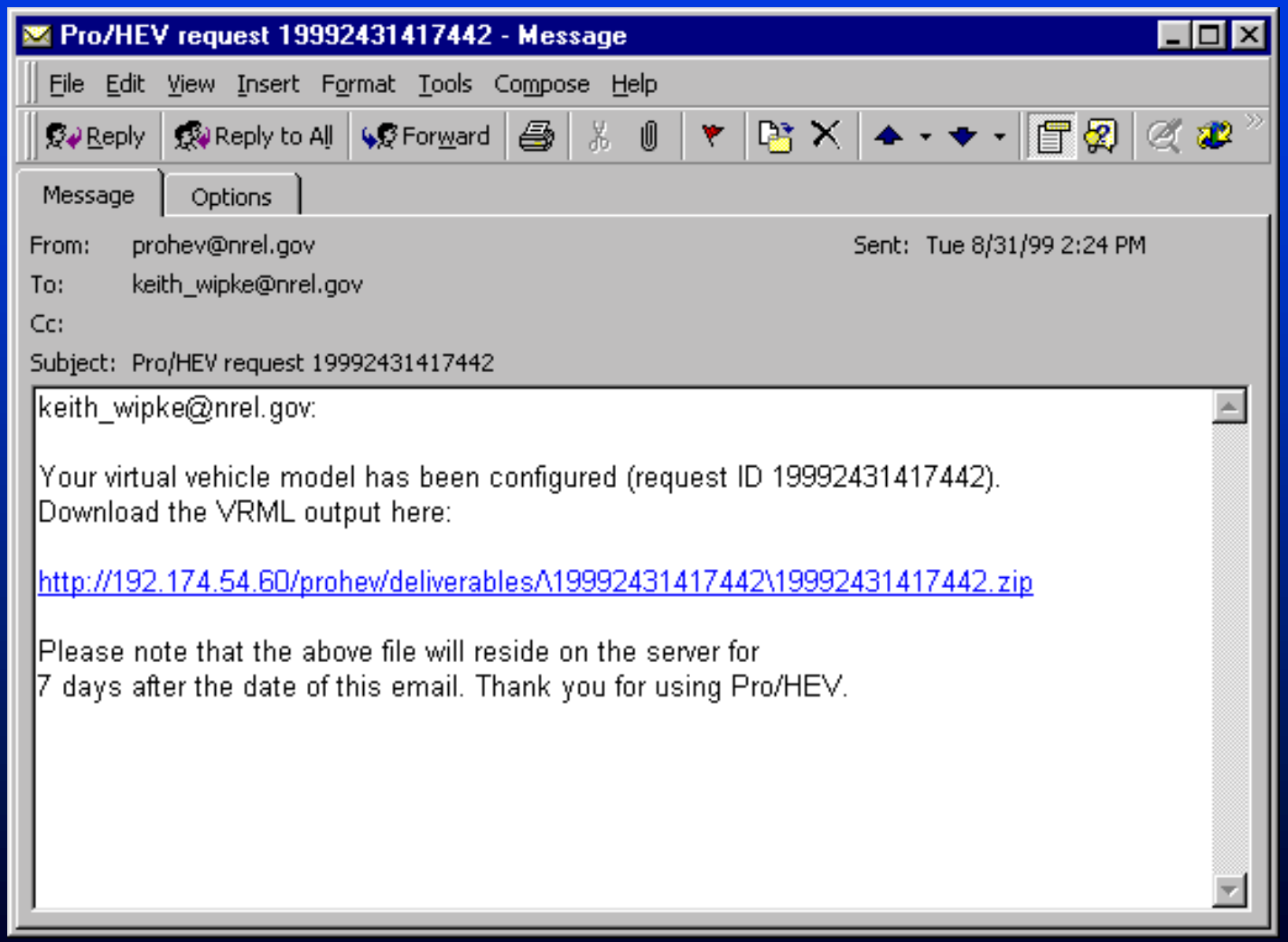
Keith Wipke, Matt Cuddy, Sam Sprik, Steve Burch, Valerie Hovland, Tony Markel.
Not pictured: Matt Keyser, Desikan Bharathan

Example of Linkage with Packaging

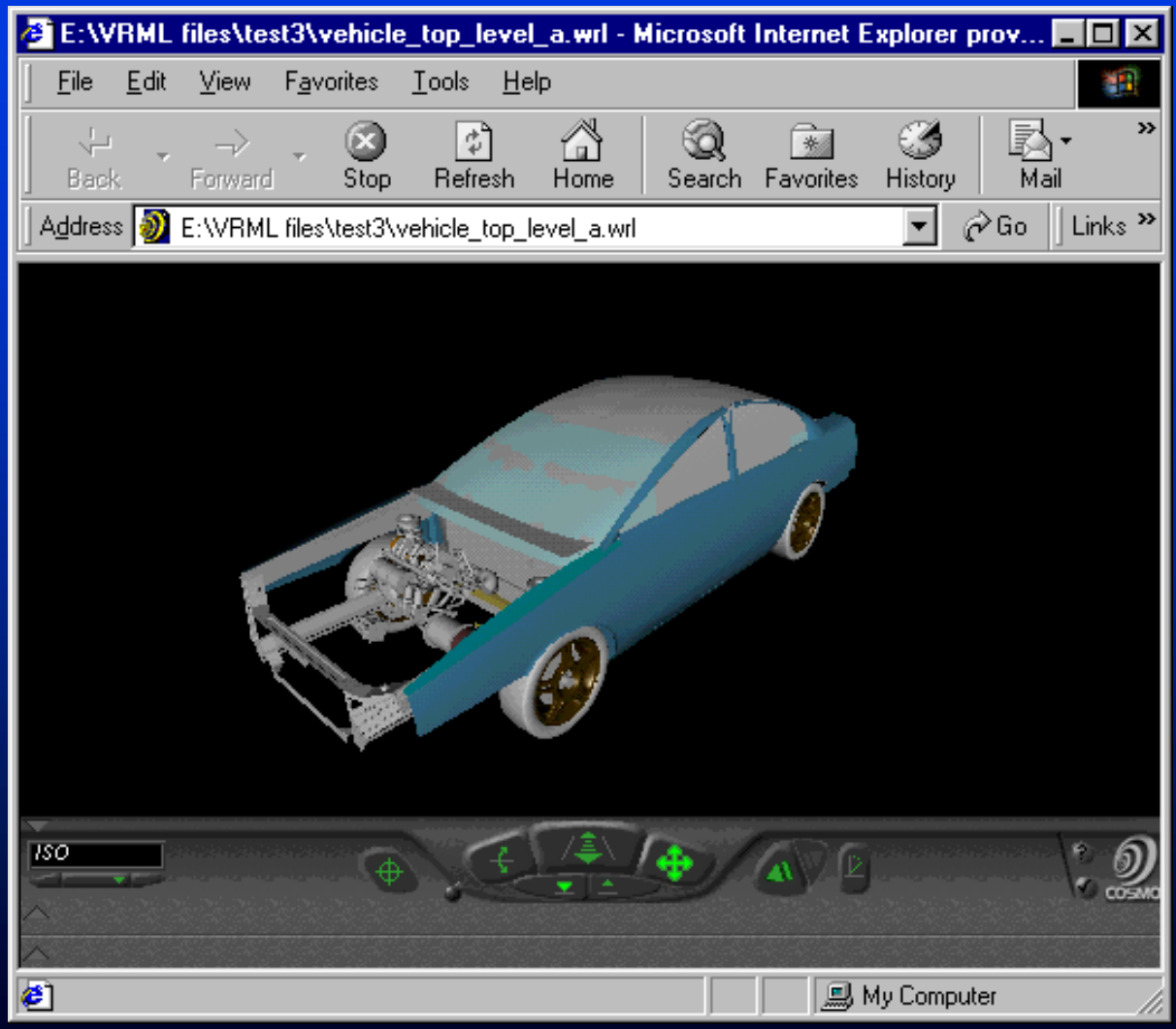


Loading ADVISOR Vehicle into Pro/HEV

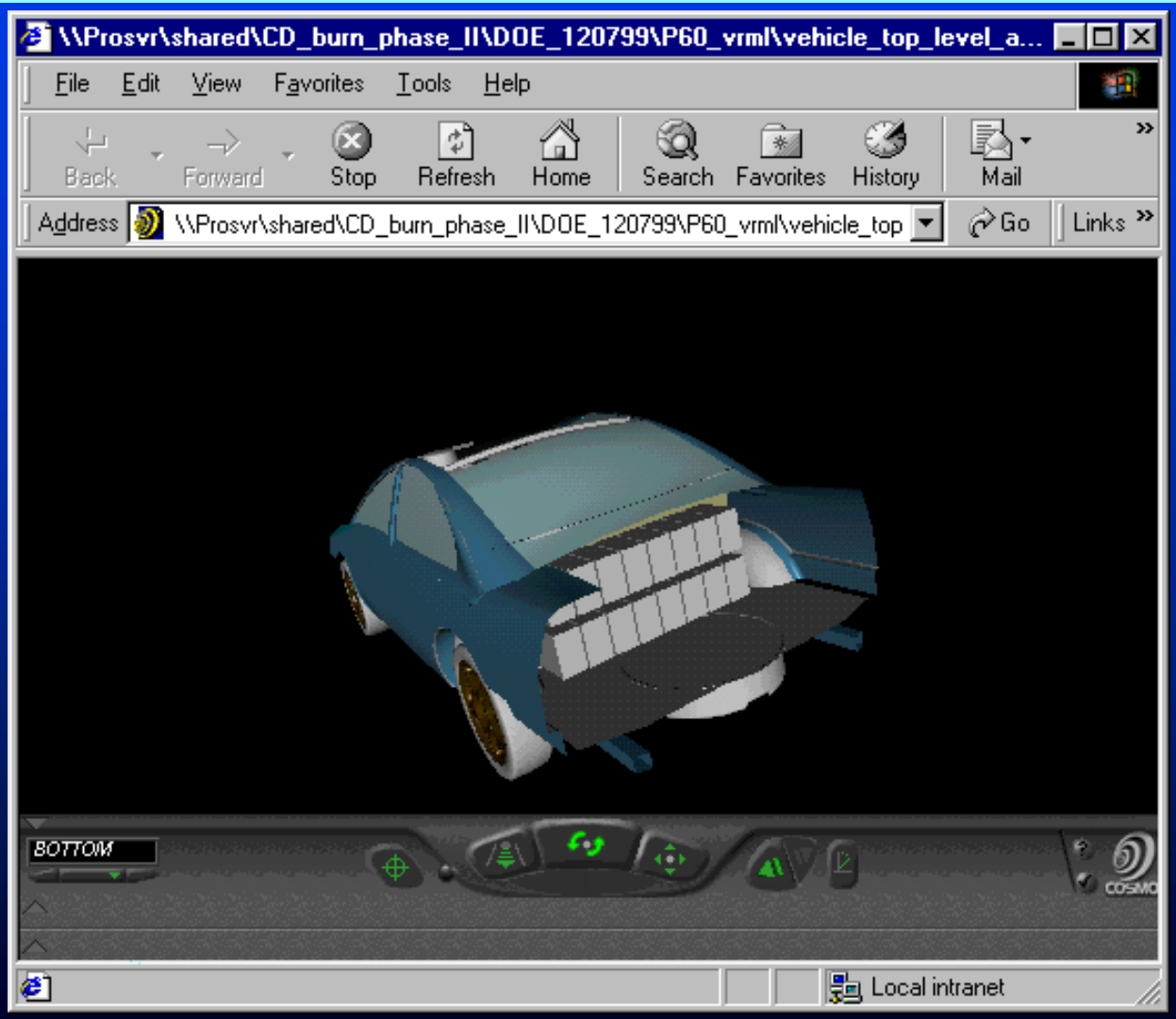
E-mail notification of VRML files



Visualizing VRML Vehicle in Browser

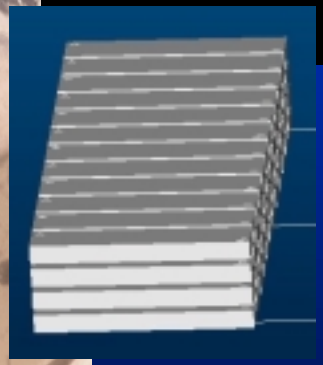


Visualizing VRML Vehicle in Browser

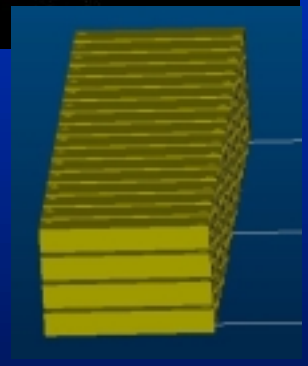


Battery Packaging Comparison from Previous Study (for illustration purposes)

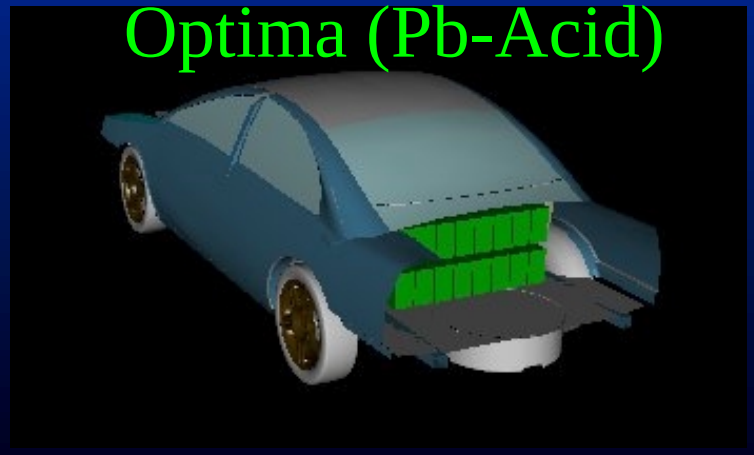
Prius (NiMH)



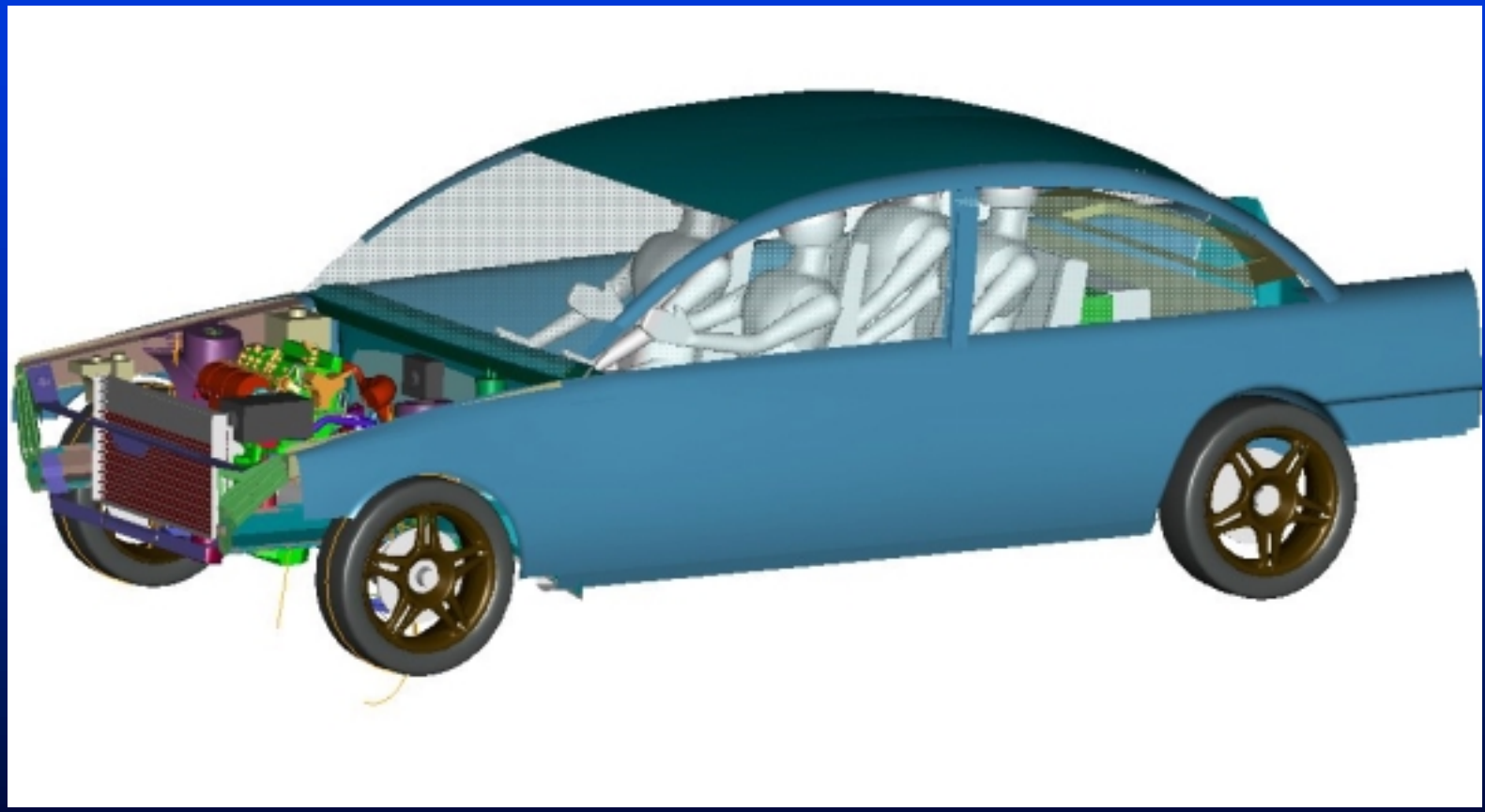
Battery “A” (Li-ion)



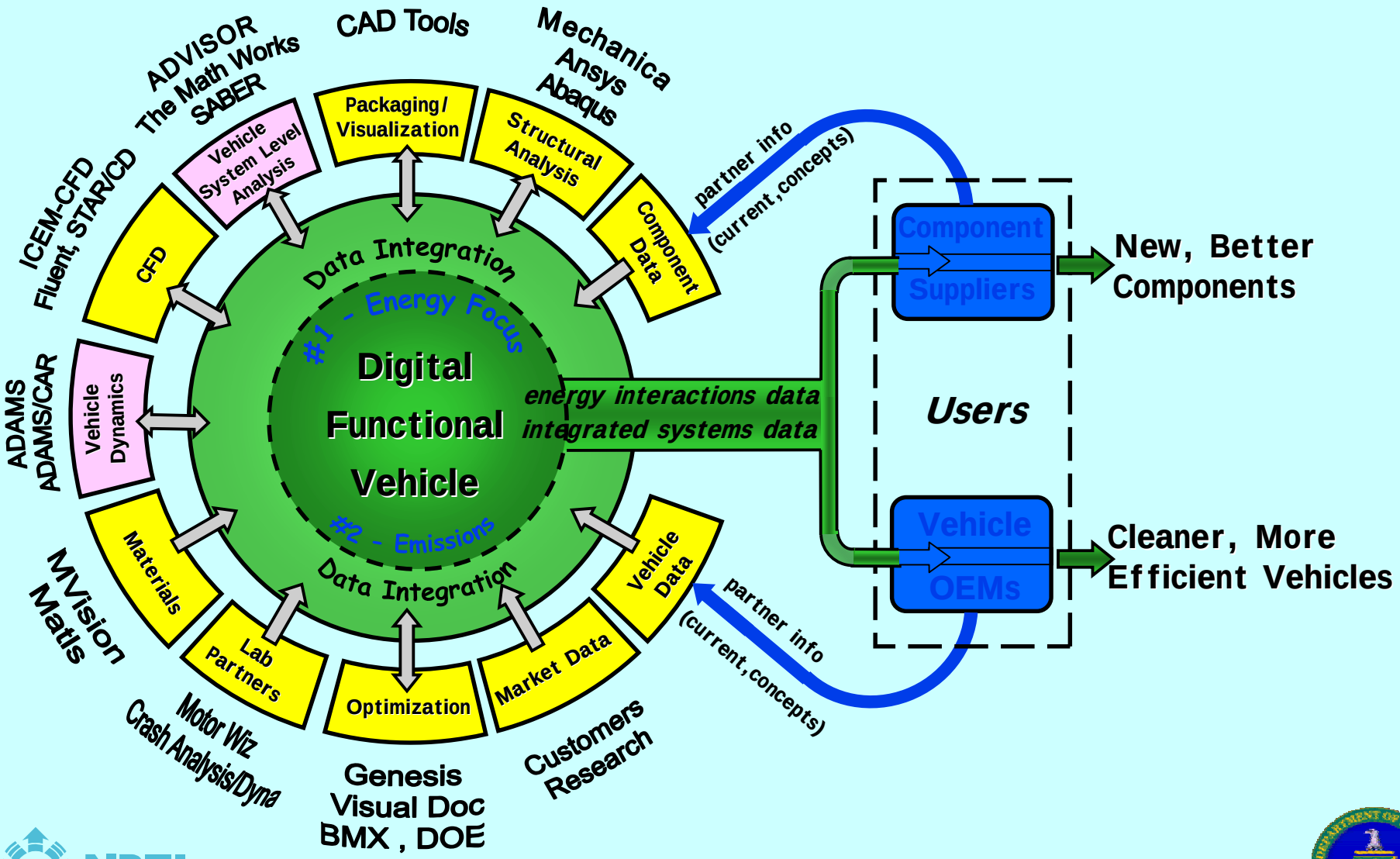
Optima (Pb-Acid)



Full Parametric Vehicle Assembly also Includes Geometry Useful for Many Groups at NREL

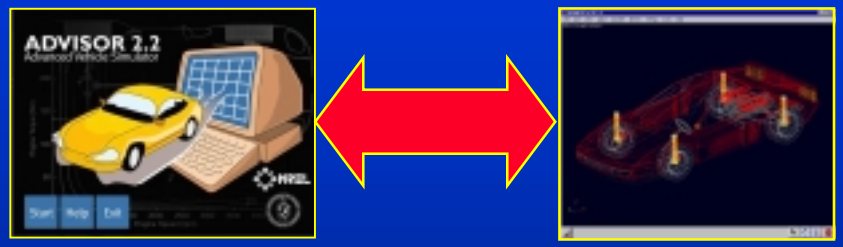


Digital Functional Vehicle Wheel: Linking Systems Level Analysis with Vehicle Dynamics

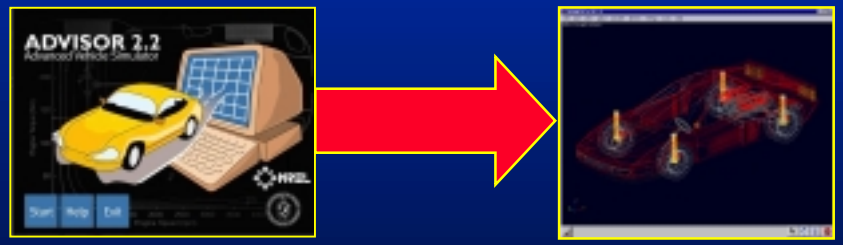


Outline:
Interfacing ADVISOR and ADAMS/Car

- Two interface approaches will be used:
  - ADAMS/ADVISOR Co-simulation



  - Export to ADAMS/Car

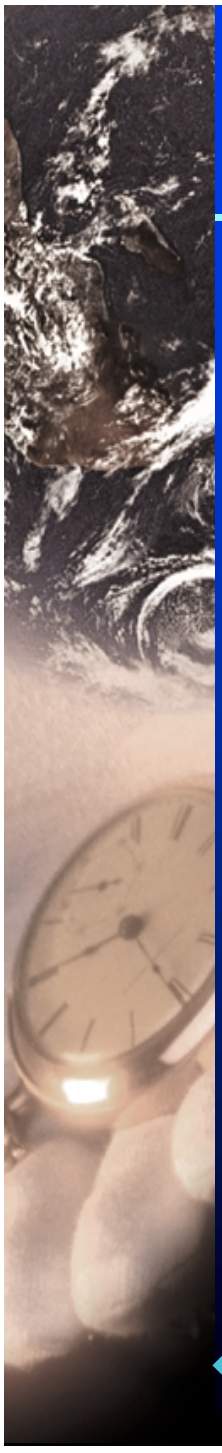


- Each approach has its own advantages and serves different simulation purposes.

ADAMS/ADVISOR Co-simulation

- ***What?***
  - Linking ADAMS/Car full vehicle model with ADVISOR model
  - Both ADAMS and Simulink solvers run together
  - Information passed back and forth between the two at each time step

- ***How?***
  - ADAMS/Car full vehicle model using customized powertrain template
  - Modified ADVISOR model to work with ADAMS/Car model

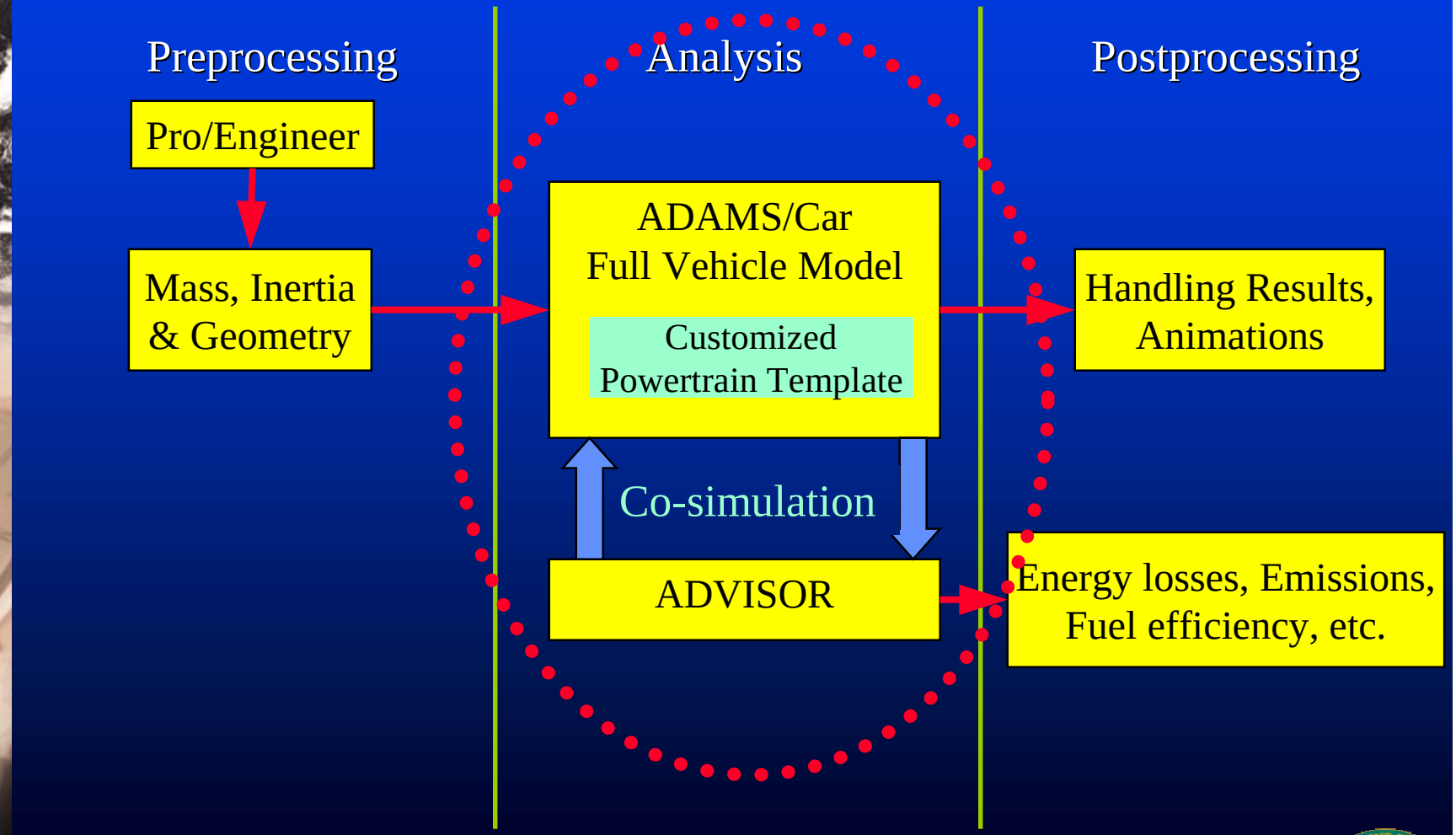


ADAMS/ADVISOR Co-simulation

- ***Why?***
  - Simulate 4WD/AWD powertrains
    - torque split can be actively controlled by ADVISOR
  - Vehicle handling/dynamics with new CM from ADVISOR
    - can look at stability issues relating to battery placement
  - Calculate energy losses during handling/durability events
    - useful for trying minimizing losses for maximum fuel efficiency
  - Integrate accessory loads (like electric power steering) and look at their energy impact vs. performance
  - Trade-offs to accurately assess impact of vehicle/component mass reduction and evaluating effect on dynamic performance
  - Perform anything you would normally do in ADAMS/Car, but using an advanced powertrain from ADVISOR

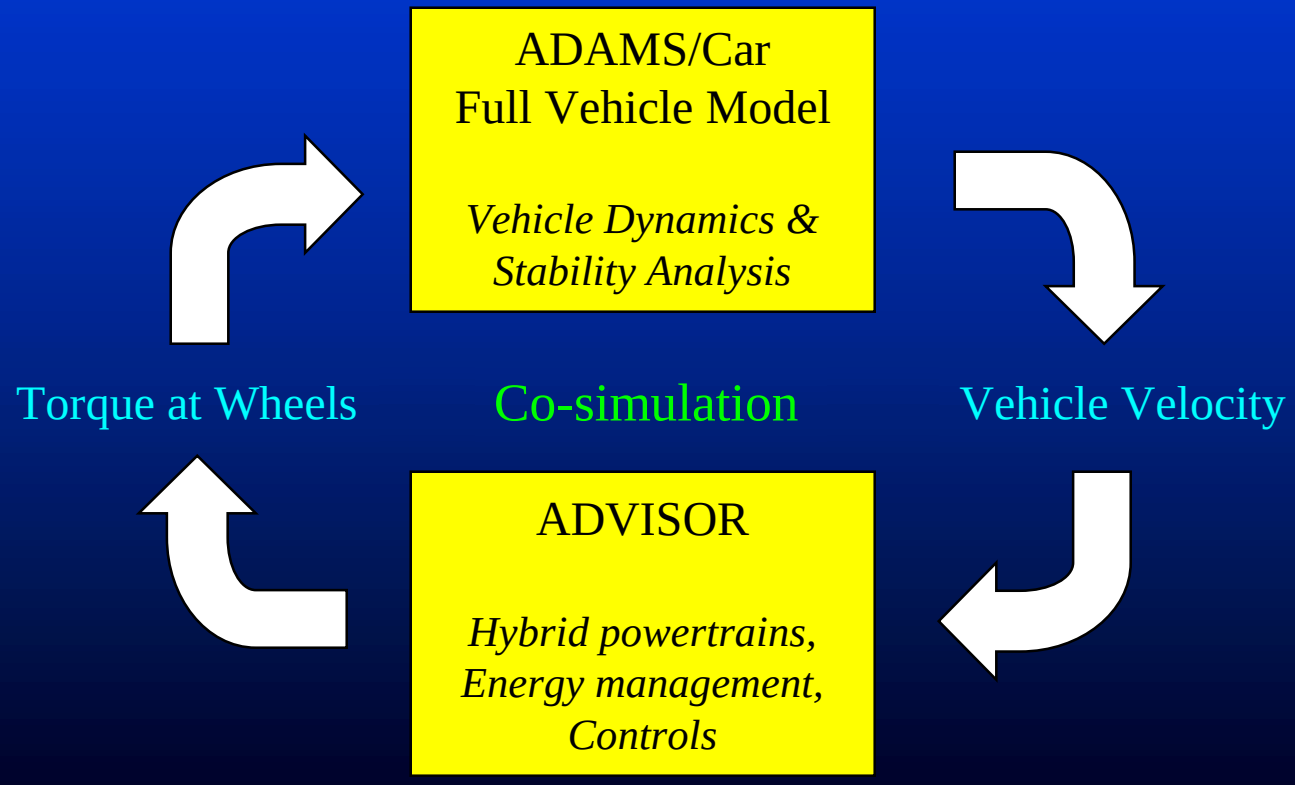
ADAMS/ADVISOR Co-simulation

- ***Overview***



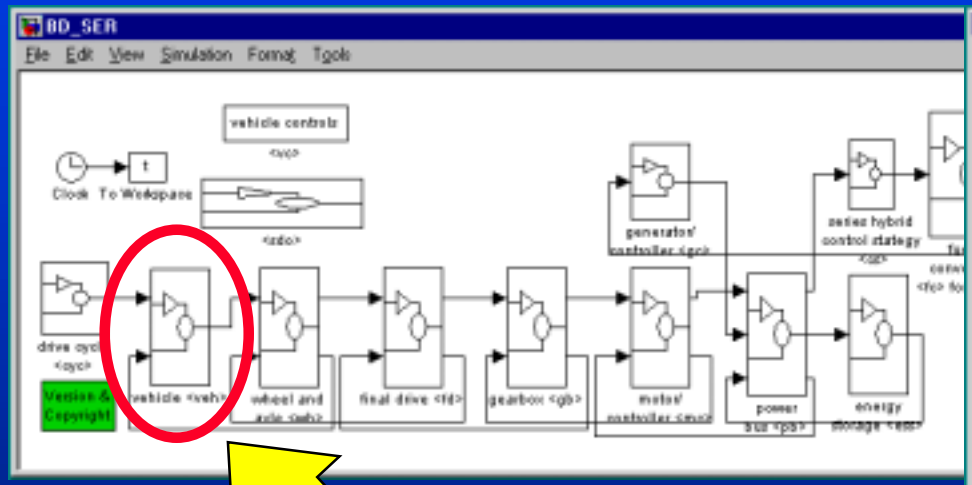
ADAMS/ADVISOR Co-simulation

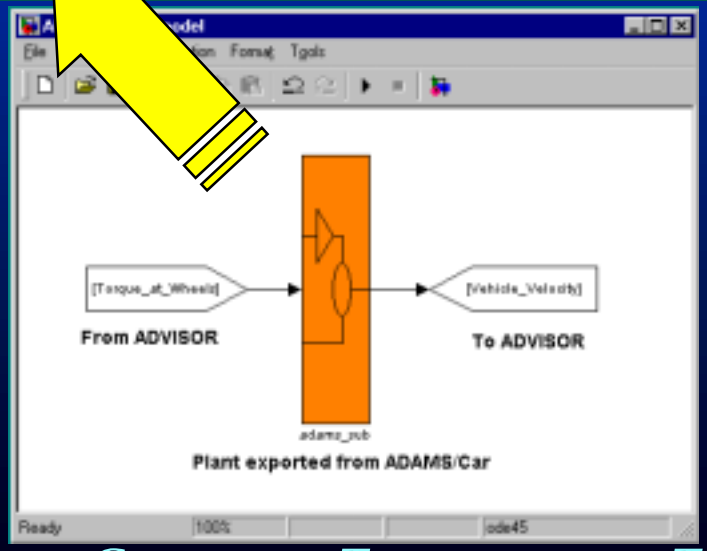
- ***Information Flow***
  - The major variables exchanged are shown below. Additional information will also be exchanged.

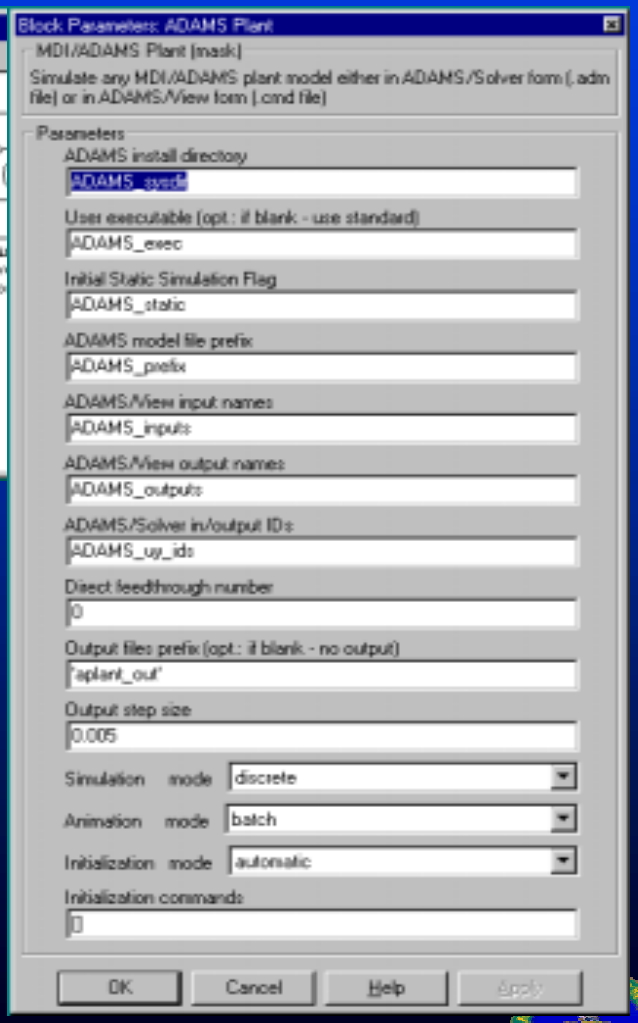


ADAMS/ADVISOR Co-simulation

- ***Exporting ADAMS/Car Plant to Simulink***





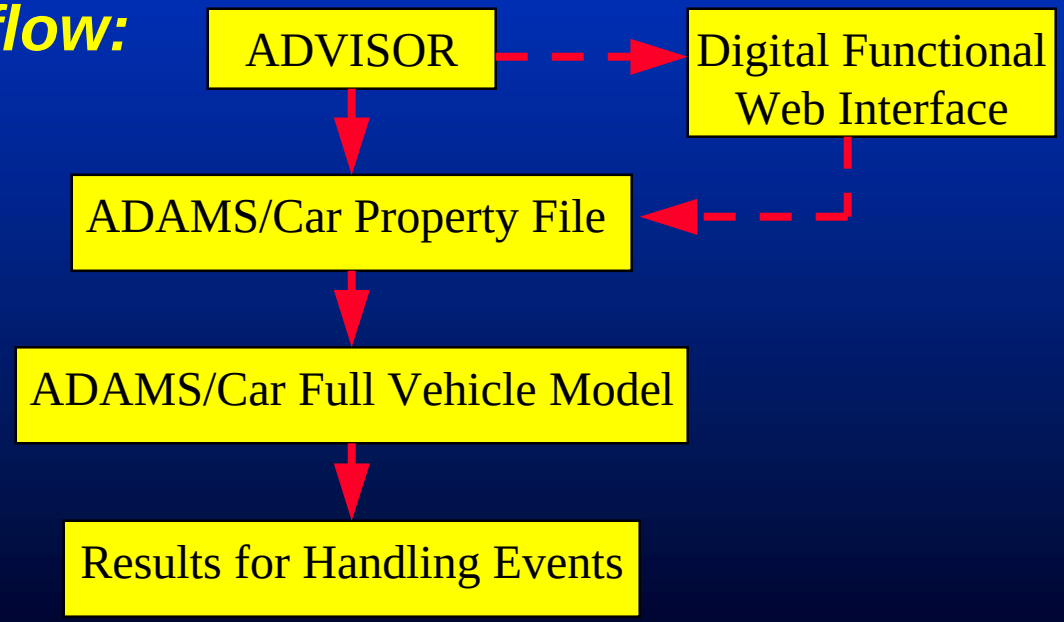


Export to ADAMS/Car

- ***What?***
  - ADAMS/Car full vehicle model with mass and inertia properties exported from ADVISOR
  - One way information flow to ADAMS/Car
- ***How?***
  - Output mass and inertia properties from ADVISOR to ADAMS/Car.
    - Optionally, geometry may be specified in web interface
  - Run standard handling maneuvers in ADAMS/Car

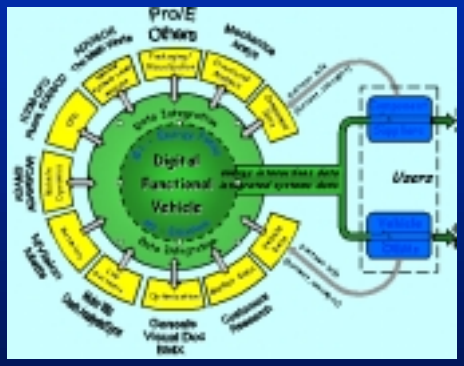
Export to ADAMS/Car

- ***Why?***
  - Faster simulations
  - Quick estimate of handling performance of hybrid vehicle
    - Example: allows analysis of battery pack location (often a large mass) and effect on handling
- ***Information flow:***



Conclusions

- ADVISOR 2.2 is a user-friendly simulation tool available to the public through the web
  - www.nrel.gov/transportation/analysis
- Widespread usage of the model globally has led to a large database of components and vehicles
- NREL is working with industry to link ADVISOR up to tools they use, such as:
  - Pro/E (visualization, packaging)
  - Visual-Doc (Optimization)
  - SABER (electrical)
  - ADAMS/Car (vehicle dynamics)



- Looking for input from active ADAMS users on how they might benefit from and guide this linkage with our advanced powertrain modeling linkage (ADVISOR)